FALCONBRIDGE

TO DEVELOP A CLEAN SMELTING PROCESS FOR HIGHLY ROASTED COPPER-NICKEL CALCINES AND TO IMPROVE METAL RECOVERY

PART C: METALLIC PHASE SATURATION BOUNDARY IN THE Ni-Cu-Fe-S SYSTEM BETWEEN 1000 AND 1300°C

by

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EXECUTIVE SUMMARY

The Falconbridge plant was originally designed for the removal of 50% of the sulphur entering the roasters. In order to reduce SO_2 emissions further, the smelter has recently increased the degree of roast to 60%. This allows more of the sulphur entering the fluidized bed roasters to be fixed as sulphuric acid, a saleable by-product.

When the degree of roast is increased, however, more heavily oxidized calcines are produced. This results in higher matte grades in the electric furnace which is detrimental to smelter metal recoveries. The countermeasure is to smelt under more intensive reducing conditions. In the presence of coke, however, a dense metallic phase forms during the smelting of the calcine. This leads to a buildup of metal on the furnace hearth, thus, reducing the capacity of the furnace and interfering with the tapping operation.

From an industrial perspective, it is desirable to ascertain the location of the matte-metal saturation boundary. For example, this boundary represents a condition of minimum oxygen potential at which point slag losses of nickel and cobalt are at their lowest.

A laboratory study was initiated in order to yield matte-metal equilibration data at temperatures ranging from 1000 to 1300°C. The compositions of the mattes (Ni, Cu, Fe, S) were in the range encountered in Falconbridge matte smelting utilizing increased degrees of roast.

The liquidus compositions and the tie-lines between the solid alloys and the liquid sulphide phases were obtained. The effect of different Ni/Cu ratios on the experimental results was examined.

SOMMAIRE

L'usine de Falconbridge a été conçue pour supprimer 50% du soufre dans les fours de grillage. Afin de réduire davantage les émissions de SO_2, la fonderie a récemment augmenté a 60% le taux de grillage. Ceci permet à une grande quantité de soufre dans le four à lit fluidisé d'être fixée en acid sulfurique, un sous-produit vendable.

L'augmentation du taux de grillage produit des calcinés à haute oxydation donnant lieu à des mattes de meilleure qualité dans les fours électriques. Ceci se fait au détriment du rendement métal de la fonderie. La contre-mesure consiste en la fonte de minerais dans des conditions de réduction plus intenses. Cependant, en présence du coke, il se forme une phase métallique dense lors de la fusion des calcinés, ce qui cause une accumulation de métal au sole du four diminuant la capacité du four et nuisant à la coulée.

Dans une perspective industrielle, il est souhaitable d'établir le seuil de saturation des mattes-métaux. Par exemple, ce seuil représente les conditions de potentiel en oxygène minimal dans lesquelles les pertes en laitier de nickel et de cobalt sont les moins importantes.

Une étude en laboratoire a été effectuée afin de déterminer les données des mattes-métaux équilibrées à des températures de 1000 à 1300°C. Les compositions des mattes (Ni, Cu, Fe, S) se situaient dans les limites obtenues lors de la fusion de mattes à des températures plus élevées de grillage à l'usine de Falconbridge.

Les compositions liquidus et les lignes d'équilibre entre les alliages solides et les phases de sulfure liquide ont été obtenues. De plus, les effets de différents rapports nickel/cuivre sur les données expérimentales on été étudiés.

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BACKGROUND

The 'Falconbridge Smelter Environmental Improvement Program' was initiated in 1978. The process circuit consists of slurry-fed fluid bed roasters for partial roasting of a nickel-copper concentrate, electric furnaces for smelting the calcine, and matte converters. The plant was originally designed to remove 50% of the sulphur entering the roasters. Under the new Environmental Improvement Program, this has been increased to 55-60%. Increasing the degree of roast results in a decrease in SO_2 emissions because more of the sulphur can be converted to sulphuric acid.

When the degree of roast is increased, more heavily oxidized calcines are produced and this results in higher matte grades in the electric furnace. Both of these effects are detrimental to smelter metal recoveries. The countermeasure is to smelt under more intensive reducing conditions. In the presence of coke, however, a metallic phase may form during the smelting of the calcine. The use of reductants to smelt partially roasted calcines lowers the sulphur level and matte grade, shifting the matte composition to the point where metallic precipitation may occur. The metallic phase has a density that is higher than the matte's. This can lead to a buildup of metal on the furnace hearth. Also, at the lower temperatures at the bottom of the furnace, metallics can precipitate from the matte.

The metallic phase saturation boundary of matte is a practical limit to furnace operations beyond which metal builds up on the hearth. The saturation boundary, however, also represents a condition of minimum oxygen potential at which point slag losses of nickel and cobalt are at their lowest. Therefore, the location of the metallic phase saturation boundary is essential to enable operation of the smelting furnace at maximum metal recovery without encountering substantial bottom buildup.

This report constitutes part C of DSS contract OSQ83-00195. It covers an investigation of the metallic phase saturation boundary in Ni-Cu-Fe-S mattes at compositions representative of electric furnace smelting. A laboratory program was initiated in order to determine the composition of mattes in equilibrium with metallics over the temperature range between 1000 and 1300°C. The results of this investigation are presented in this report.

LABORATORY STUDY OBJECTIVES

The laboratory study was initiated in order to yield matte-metal equilibration data at temperatures ranging from 1000 to 1300°C (1273-1573 K). The compositions of the mattes (Ni, Cu, Fe, S) were in the range encountered in Falconbridge matte smelting utilizing increased degrees of roast. The tests were performed in sealed tubes and metallics were added in the form of a ferronickel alloy. The equilibration reaction between matte and metallics resulted in the formation of a new metallic phase in equilibrium with molten matte. The analysis of these mattes and the new metallic phases provided the data necessary to construct tie-lines between the two phases.

The main objective was the estimation of the liquidus temperatures. This information is of value in predicting alloy formation at various temperatures as there is a vertical temperature gradient throughout the electric furnace.

EQUIPMENT

Furnace and Controller

A Marshall resistance-type furnace was used in the high temperature equilibration tests. Specifications on furnace and auxiliary equipment are given as follows:

Furnace:	"Marshall" (1600°C max.) Power - 15KVA - Single Phase Frequency - 60 Hz Maximum Current Draw - 138 A
Controller:	Eurotherm SCR Analog (Model 917) Thermocouple Type "B" actuated (Pt/6% Rh vs Pt/30% Rh)
Heating Elements:	5 Super Kanthal 33"
Heated Chamber:	4-1/8" x 24"
Charge Temperature Measurement:	Thermocouple (Pt vs Pt/10% Rh) Omega Digital Thermometer
Furnace Inner Tube:	Alumina O.D. 3-3/4" I.D. 3-1/4" Length 48"

Electron Probe Microanalyser

Cambridge Mark V electron-probe microanalyser with LINK 860 Energy Dispersive Detector, 20 kV, 10 µA, pure element standards. LINK ZAF4 Data Reduction Software.

MATERIALS

Ferronickel Alloys

High purity Falconbridge Granular Nickel and high purity iron powder were used to prepare a series of ferronickel alloys containing 10 to 60% Ni. The appropriate masses of nickel and iron (50.0 g total) were heated in a fireclay crucible in an induction furnace. The sample was melted, and then maintained at a temperature greater than 1600°C for 5 minutes. The sample was then cooled to room temperature. The solidified melt was ground clean and milled to obtain fine chips.

FeS

Reagent grade FeS was obtained from two suppliers: Sargent-Welch and Fisher Scientific. Oxygen was removed by placing 500 g of material in a pre-heated fireclay crucible and purging with hydrogen (3 l/min) for 30 min. The material was then heated to 1250°C, held at that temperature in a gas fired pot furnace, and subsequently cooled under hydrogen. The final material analysed:

Source	Analysis (mass %)		
	Fe	S	O
Fisher	65.3	31.9	0.74
Sargent Welch	71.8	26.5	0.32

The Fisher material was closer to stoichiometric FeS (i.e. 63.6% Fe). Differences can be attributed to the preparation technique which appears to have resulted in hydrogen sulphide evolution and some metallics formation. The analysis of the 'FeS' was taken into account when preparing the matte samples.

Metal Powders

High purity metal powders included Mond Carbonyl Nickel powder and BDH reagent grade iron powder.

Ni_3S_2

Nickel sulphide (Ni_3S_2) was prepared from carbonyl nickel powder and elemental sulphur. Stoichiometric amounts of nickel and sulphur were mixed, then transferred to a fireclay crucible. The crucible was covered and purged with argon before being heated to 900°C. The ensuing reaction is exothermic, but controlled. The contents of the crucible were cooled under argon and then crushed and ground.

Cu_2S

Reagent grade Cu_2S was used as received.

PROCEDURE

Melt Compositions

A computer spreadsheet program was used to calculate the masses of sulphides and metals needed for each experiment. The program was based on an initial target matte composition. The compositions of the initial sulphides and metals were input, along with the starting mass of Cu_2S (usually 10.0 g). The computer provided sequential calculations of Ni_3S_2, FeS and Fe, as well as the total mass of the matte.

The composition and mass of the ferronickel alloy (usually 10.0 g) were input, and a final overall composition and mass were provided as output by the computer.

Charge Preparation

Quartz tubing (6 mm i.d., 10 mm o.d.) was used in all of the tests. A 40 cm length of tube was sealed at one end using an oxy-acetylene torch. All moisture was removed in order to prevent the dry powders from sticking to the inside wall of the tube.

Ferronickel chips were fed into the tube through a small funnel, followed by the required amounts of Cu_2S, FeS, Ni_3S_2, and Fe powders. The tube was then mounted vertically and connected to a vacuum pump. When the pressure had been reduced to approximately 0.1 mm Hg, the bottom of the tube was slowly rotated, causing the viscous quartz to twist around its own axis. After 4-5 turns, the top of the quartz was shaped into a small hook. This hook was used for suspending the charge in the furnace.

Chromel wire (1.0 mm diameter) was cut into 13 cm lengths. These sections were looped together to form a sample suspension chain. Samples were suspended vertically in the hot zone of the furnace.

Furnace and Sample Treatment

The furnace was controlled at the desired temperature. An argon atmosphere was maintained during the charge treatment period to minimize oxidation of the wire. The sealed specimen was suspended in the hot zone of the furnace for 24-48 hours. The bottom of the furnace was then opened and the suspension wire was cut, allowing the vial to drop into a water quench tank. The shattered quartz was removed and the pins of matte/alloy were recovered and dried at 110°C for 1 hour.

The bottom tip of the charge (containing the alloy) was broken away from the matte. A polished section of the alloy matrix was prepared and analysed for Cu, Ni and Cu by electron probe techniques.

The matte was stage ground to -48 mesh and examined for metallics. Generally, the metallic particles had settled but the occasional metallic particle was removed from the matte. The matte was then ground to -100 mesh and analysed for Ni, Cu, Fe, O and S. Metals were determined by atomic absorption methods. Sulphur and oxygen were determined by combustion procedures (LECO Instruments).

RESULTS

Preliminary Tests

A series of tests was performed in order to determine the optimum residence time in the furnace to obtain a sufficient quantity of the new alloy phase for analysis.

An initial matte mixture was prepared from the following:

Cu_2S	21.88 g
Ni_3S_2	23.86 g
FeS	53.84 g
Fe	1.35 g
	100.93 g

Five ampoules were prepared according to the aforementioned procedure. The matte mixture (6.03 g) and FeNi chips (1.32 g, 20% Ni-80% Fe) were transferred to the quartz tubes. All five ampoules were heated in the furnace at 1100°C, with an ampoule being removed after 3, 6, 15, 24 and 48 hours. Each sample was examined visually and microscopically and the following results were obtained:

Test #	Hours	Notes
1	3	Alloy chips retained original morphology
2	6	Change in composition at the alloy's surface
3	15	Change in alloy composition
4	24	Change in alloy composition
5	48	Majority of metallics as new phase

The tube from test #5 had collapsed. All alloys were, however, separated and mounted as polished sections for scanning. The 48 hour test showed the maximum amount (i.e. thickness) of new alloy phase surrounding the original alloy. The new phase analysed 30% Ni, as compared to 20% for the core alloy. The new alloy thickness was approximately 400 microns and this was more than sufficient for probe analysis.

Owing to the problems associated with the tube collapse, a 24 hour equilibration period was used for subsequent tests at 1100°C. Some tests at 1000°C were performed for 48 hours.

Equilibration Studies

The results of the analysis of 53 matte and alloy samples are given in Table 1. Several samples were not recovered, and due to various factors, some of the alloys could not be analysed. For example, in some cases the grain size was <10 microns, making probe analysis difficult.

The tie-line data from the equilibration studies are presented graphically in Figures 1-4 for 1000, 1100, 1200 and 1300°C, respectively. Tie-lines between the matte and alloy phases run parallel in most cases, however, there are several exceptions. Only a limited number of data points were obtained at 1300°C due to difficulties encountered in recovering the samples.

Attempts were made to minimize oxygen in the mattes - both in the source materials and in the experimental procedures. Oxygen concentrations are in the 1.5% range, and some of this was probably introduced during the sample drying and preparation stages.

The results presented in Figures 1-4 have been normalized to ensure that

$$\sum(Cu+Ni+Fe+S+O)$$

totals 100% for each of the matte samples. The tie-lines are shown connecting the Fe-(Ni+Cu) axes. This assumption was based on the work of Lenz et al. (6). In their study, the sulphur content of the alloy phase contained between 0.04 and 0.06 mass % S. Their tie-lines were drawn connecting the Fe-Ni binary.

DISCUSSION

Matte-Metallics Saturation in Ni, Cu, Fe Mattes

Binary metal-sulphur phase diagrams indicate that on contacting the liquidus curve, a sulphur-free metal will precipitate. Binary metal-sulphur diagrams (Ni-S, Cu-S, Fe-S) are shown in Figures 5-7 (1-3). For the Fe-Ni-S ternary system, shown as a pseudo-binary (Fe/Ni = 1.5) in Figure 8 (4), it can be seen that a sulphur-free ferro-nickel alloy is precipitated on contacting the liquidus. Vanyukov et al. (5) have determined the liquidus in the Fe-Ni-S system. Lenz et al. (6) have constructed tie-lines in the same system at temperatures between 1200 and 1400°C. A computer literature search relating to the quaternary Fe-Ni-Cu-S system was conducted through Dialog Information Services. The only paper of relevance was by Sobolev et al. (7), namely: "Investigation of the Cu-Ni-Fe-S System as Applicable to the Processing of Cu-Ni Ores". A comparison between Sobolev's work and this work will be described later in the text.

An examination of the data presented in Figures 1-4 reveals that there is some scatter in the results. This could be caused by two main factors:

1) analytical errors

2) different Ni/Cu ratios

In the analysis of the mattes (Table 1), the $\sum(Cu+Ni+Fe+S+O)$ quantity ranged between 93.40 to 102.75%. This gives an indication of the difficulties encountered in analysing the various components of a matte sample.

The effect of different Ni/Cu ratios would also be expected to influence the location of the data points on a ternary diagram when Ni+Cu are combined as a single component. For example, consider the results presented in Figure 9. In general, it can be seen that for each series of mattes, the higher the Ni/Cu ratio, the lower the sulphur content.

The curves drawn to fit the data points in Figures 1-4 represent, therefore, the average Ni/Cu ratios for all of the tests. In fact, the points on these figures are points on a family of curves with different Ni/Cu ratios. This is shown in Figure 10 for two different Ni/Cu ranges at 1100°C. Similar results were obtained at 1200°C . These results are presented in Figures 11 and 12.

The results of the tests obtained at 1100 and 1200°C are compared with published metal saturation boundary data for the Cu-Fe-S and the Ni-Fe-S ternary systems. These are presented in Figures 13 and 14. The data in Figure 13 (1100°C) shows the Ni-Fe-S and Cu-Fe-S systems obtained from Vogel and Tonn (4) and Reuleaux (8), respectively. The data in Figure 14 (1200°C) were obtained from Lenz et al. (6) and Reuleaux (8). The experimental values obtained using the Ni-Cu-Fe-S system fall close to the Cu-Fe-S saturation boundary. The alloy precipitated in the current study is nickel rich with a copper content varying between 1.4 to 7.4 mass percent. The average copper content of the alloy phase is in the order of 4%. The results plotted in Figures 13 and 14 have total S+O as one of the sides of the triangle. This has the effect of shifting the saturation boundary slightly towards the sulphur apex.

Tests at 1200°C indicate that for low grade mattes (Σ(Ni+Cu) = 22%;Ni/Cu= ~1.0), the alloy composition will approximate 21.5% Ni, 3.5% Cu and 75% Fe. For higher grade mattes at 1200°C (Σ(Ni+Cu) = 30), the alloy composition will approximate 30.5% Ni, 5% Cu and 64.5% Fe. Samples taken from electric furnace buildup have analysed, on average, 42.1% Ni+Co, 3.4% Cu and 54.3% Fe.

The liquidus curves obtained in this study are in excellent agreement with those obtained by Sobolev et al. (7) (with Ni:Cu=1). For example, results obtained by these investigators at 1100°C are superimposed on Figure 10. Similar agreement was obtained at other temperatures. It should be noted that in the present investigation one of the apices of the composition triangle is Σ(S+O). Sobolev et al. (7) do not measure the oxygen content of their samples and simply plot their results using % S.

The data obtained in this study are important from an industrial perspective. As previously explained, under the 'Environmental Improvement Program', the amount of sulphur elimination in the roasters has been increased to approximately 60%. This increase results in more heavily oxidized calcines and higher matte grades in the electric furnace. Both effects are detrimental to smelter metal recoveries. The counter-measure is to smelt under more intensive reducing conditions by raising the reductant feedrate. One limit to the coke additions is when the matte composition reaches the metal saturation boundary. In this study it was shown that the temperature of the system, as well as the Ni/Cu ratio of the matte affect the saturation boundary. A decrease in the temperature shifts the boundary towards the sulphur apex and to lower iron levels.

In the coke reduction zone, the appearance of a metallic phase fixes the thermodynamic conditions with respect to the oxygen potential of the system. This limit is critical to metal recovery as the nickel and cobalt losses to the slag are related to the oxygen potential. In the bulk matte zone, the precipitation of metallics can lead to a buildup of crusts on the furnace hearth because the metallic phase has a density that is higher than the matte's. It is desirable to maintain some frozen material on the hearth, however, excessive buildups reduce the capacity of the furnace and intefere with tapping of the furnace.

The amount of metallic iron in the furnace matte is affected by the addition of coke. The iron content is a measure of the reducing potential of the furnace. In general, the higher the iron level in the matte, the higher are the metal recoveries. The penalty for raising the metallic iron level is an increase in the melting point of the matte. This further aggravates the buildup problem on the hearth. The metallic iron in the matte also influences the operation of the converters since this iron provides substantial heat release during the converting operation.

Before the, 'Falconbridge Environmental Improvement Program' can be successfully implemented, the complex relationships concerning coke addition, metal precipitation, nickel recovery, and production costs must be investigated and fully understood.

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TABLE 1 - EXPERIMENTAL DATA

MATTE PHASE														ALLOY PHASE				
RAW DATA (MASS %)						NORMALIZED (MASS %)												
Ni-Matte	Cu-Matte	Fe-Matte	S-Matte	O-Matte	Sum-Matte	Norm-Ni	Norm-Cu	Norm-Fe	Norm-S	Norm-O	Ni+Cu	S+O	Ni/Cu	Ni-Met	Cu-Met	Fe-Met	T (°C)	TEST #
15.70	15.90	39.00	24.30	1.10	96.00	16.35	16.56	40.63	25.31	1.15	32.92	26.46	0.99	32.00	4.40	63.60	1100	1
12.40	11.50	46.00	24.40	1.70	96.00	12.92	11.98	47.92	25.42	1.77	24.90	27.19	1.08	23.20	2.80	73.00	1100	2
9.92	8.73	50.00	25.40	1.40	95.45	10.39	9.15	52.38	26.61	1.47	19.54	28.08	1.14	18.10	1.80	78.90	1100	3
22.00	18.20	33.00	21.60	1.20	96.00	22.92	18.96	34.38	22.50	1.25	41.88	23.75	1.21	41.90	6.50	51.90	1100	4
18.30	13.00	39.00	23.60	1.60	95.50	19.16	13.61	40.84	24.71	1.68	32.77	26.39	1.41	35.50	4.10	60.10	1100	5
14.50	9.74	47.00	22.90	1.40	95.54	15.18	10.19	49.19	23.97	1.47	25.37	25.43	1.49	25.40	2.60	71.10	1100	6
11.30	7.34	52.00	23.90	1.20	95.74	11.80	7.67	54.31	24.96	1.25	19.47	26.22	1.54	18.50	1.60	78.00	1100	7
24.00	16.10	33.00	21.70	1.10	95.90	25.03	16.79	34.41	22.63	1.15	41.81	23.77	1.49	45.30	5.70	49.40	1100	8
17.30	15.30	39.00	23.90	1.60	97.10	17.82	15.76	40.16	24.61	1.65	33.57	26.26	1.13	34.50	4.20	60.40	1100	9
9.80	8.80	48.00	27.20	1.50	95.30	10.28	9.23	50.37	28.54	1.57	19.52	30.12	1.11	19.70	1.40	76.20	1000	10
13.70	13.40	41.00	25.90	1.50	95.50	14.35	14.03	42.93	27.12	1.57	28.38	28.69	1.02	31.40	2.90	64.40	1000	11
17.60	16.10	36.00	25.20	1.20	96.10	18.31	16.75	37.46	26.22	1.25	35.07	27.47	1.09	40.90	4.20	55.70	1000	12
18.40	20.10	32.00	24.00	1.70	96.20	19.13	20.89	33.26	24.95	1.77	40.02	26.72	0.92	44.20	5.70	50.30	1000	13
10.80	7.80	49.00	26.80	1.60	96.00	11.25	8.13	51.04	27.92	1.67	19.38	29.58	1.38	21.30	1.40	77.00	1000	14
15.20	11.80	41.00	25.80	1.60	95.40	15.93	12.37	42.98	27.04	1.68	28.30	28.72	1.29	32.70	2.70	62.80	1000	15
19.30	14.00	37.00	25.00	1.40	96.70	19.96	14.48	38.26	25.85	1.45	34.44	27.30	1.38	41.50	4.00	54.80	1000	16
20.40	17.70	32.00	24.30	1.60	96.00	21.25	18.44	33.33	25.31	1.67	39.69	26.98	1.15	46.50	5.20	48.60	1000	17
10.90	7.30	51.00	22.70	2.20	94.10	11.58	7.76	54.20	24.12	2.34	19.34	26.46	1.49	17.00	2.20	79.70	1200	18
14.90	10.40	45.00	22.30	1.50	94.10	15.83	11.05	47.82	23.70	1.59	26.89	25.29	1.43	23.70	3.40	70.90	1200	19
18.40	13.70	40.00	21.10	2.00	95.20	19.33	14.39	42.02	22.16	2.10	33.72	24.26	1.34	31.30	5.00	62.50	1200	20
22.20	16.30	34.00	19.70	1.20	93.40	23.77	17.45	36.40	21.09	1.28	41.22	22.38	1.36	37.00	7.40	53.20	1200	21
11.70	6.40	51.00	23.00	1.50	93.60	12.50	6.84	54.49	24.57	1.60	19.34	26.18	1.83	17.10	2.00	80.40	1200	22
16.30	8.80	46.00	21.90	1.30	94.30	17.29	9.33	48.78	23.22	1.38	26.62	24.60	1.85	28.70	2.60	67.20	1200	23
21.00	11.70	40.00	20.70	1.70	95.10	22.08	12.30	42.06	21.77	1.79	34.38	23.55	1.79	33.60	4.50	61.30	1200	24
24.80	15.00	35.00	19.00	1.20	95.00	26.11	15.79	36.84	20.00	1.26	41.89	21.26	1.65	39.90	6.70	52.70	1200	25
15.80	16.30	41.30	24.70	0.88	98.98	15.96	16.47	41.73	24.95	0.89	32.43	25.84	0.97	30.80	3.96	65.20	1100	26
19.20	14.40	41.60	24.70	1.16	101.06	19.00	14.25	41.16	24.44	1.15	33.25	25.59	1.33	36.40	4.02	59.50	1100	27
14.00	11.60	48.20	26.30	0.93	101.03	13.86	11.48	47.71	26.03	0.92	25.34	26.95	1.21	26.30	2.55	71.00	1100	28
10.80	8.60	53.60	26.70	1.03	100.73	10.72	8.54	53.21	26.51	1.02	19.26	27.53	1.26	19.30	1.81	78.70	1100	29
18.80	15.00	42.20	24.50	0.81	101.31	18.56	14.81	41.65	24.18	0.80	33.36	24.98	1.25	31.60	3.96	64.30	1100	30
11.40	8.80	51.20	25.20	1.11	97.71	11.67	9.01	52.40	25.79	1.14	20.67	26.93	1.30	-	-	-	1200	31
22.60	19.90	35.20	22.40	0.68	100.78	22.43	19.75	34.93	22.23	0.67	42.17	22.90	1.14	39.70	6.82	53.30	1200	32
19.80	15.70	40.00	23.60	0.80	99.90	19.82	15.72	40.04	23.62	0.80	35.54	24.42	1.26	-	-	-	1200	33
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1300	34
23.50	19.60	33.60	21.70	1.10	99.50	23.62	19.70	33.77	21.81	1.11	43.32	22.91	1.20	49.60	5.75	44.50	1300	35
15.50	13.00	45.20	24.20	0.00	97.90	15.83	13.28	46.17	24.72	0.00	29.11	24.72	1.19	32.10	3.43	64.40	1300	36
10.70	10.00	53.00	25.90	0.89	100.49	10.65	9.95	52.74	25.77	0.89	20.60	26.66	1.07	21.30	1.94	76.60	1200	37
24.20	19.50	34.00	21.90	1.02	100.62	24.05	19.38	33.79	21.77	1.01	43.43	22.78	1.24	43.30	7.06	49.60	1200	38
15.30	13.60	45.80	25.30	1.00	101.00	15.15	13.47	45.35	25.05	0.99	28.61	26.04	1.13	29.00	3.09	67.80	1200	39
10.30	9.60	51.50	26.30	1.38	99.08	10.40	9.69	51.98	26.54	1.39	20.08	27.94	1.07	19.00	1.95	78.90	1100	40
21.00	20.80	34.30	23.40	1.29	100.79	20.84	20.64	34.03	23.22	1.28	41.47	24.50	1.01	41.20	5.90	52.80	1100	41
18.30	16.00	39.80	24.30	1.38	99.78	18.34	16.04	39.89	24.35	1.38	34.38	25.74	1.14	36.30	3.91	59.60	1100	42
11.50	10.80	51.50	22.60	1.22	97.62	11.78	11.06	52.76	23.15	1.25	22.84	24.40	1.06	17.80	2.78	79.30	1300	43
13.50	11.80	50.50	21.50	1.23	98.53	13.70	11.98	51.25	21.82	1.25	25.68	23.07	1.14	24.90	5.24	64.30	1300	44
16.30	13.00	46.50	21.30	1.14	98.24	16.59	13.23	47.33	21.68	1.16	29.82	22.84	1.25	32.30	3.51	64.10	1300	45
19.30	15.50	45.30	17.60	1.17	98.87	19.52	15.68	45.82	17.80	1.18	35.20	18.98	1.25	-	-	-	1300	46
22.50	17.30	39.00	18.80	0.94	98.54	22.83	17.56	39.58	19.08	0.95	40.39	20.03	1.30	-	-	-	1300	47
9.80	10.40	58.80	22.60	1.15	102.75	9.54	10.12	57.23	22.00	1.12	19.66	23.11	0.94	14.80	2.50	82.60	1200	48
12.00	13.80	50.60	23.50	1.01	100.91	11.89	13.68	50.14	23.29	1.00	25.57	24.29	0.87	22.50	3.63	73.90	1200	49
19.00	17.60	41.60	22.10	0.95	101.25	18.77	17.38	41.09	21.83	0.94	36.15	22.77	1.08	33.90	5.14	60.90	1200	50
16.20	16.40	46.00	20.10	1.38	100.08	16.19	16.39	45.96	20.08	1.38	32.57	21.46	0.99	51.10	3.64	45.20	1000	51
21.60	22.00	32.00	23.80	0.98	100.38	21.52	21.92	31.88	23.71	0.98	43.43	24.69	0.98	47.50	5.46	47.00	1000	52
10.60	14.00	49.60	24.90	1.23	100.33	10.57	13.95	49.44	24.82	1.23	24.52	26.04	0.76	23.50	2.63	73.80	1000	53

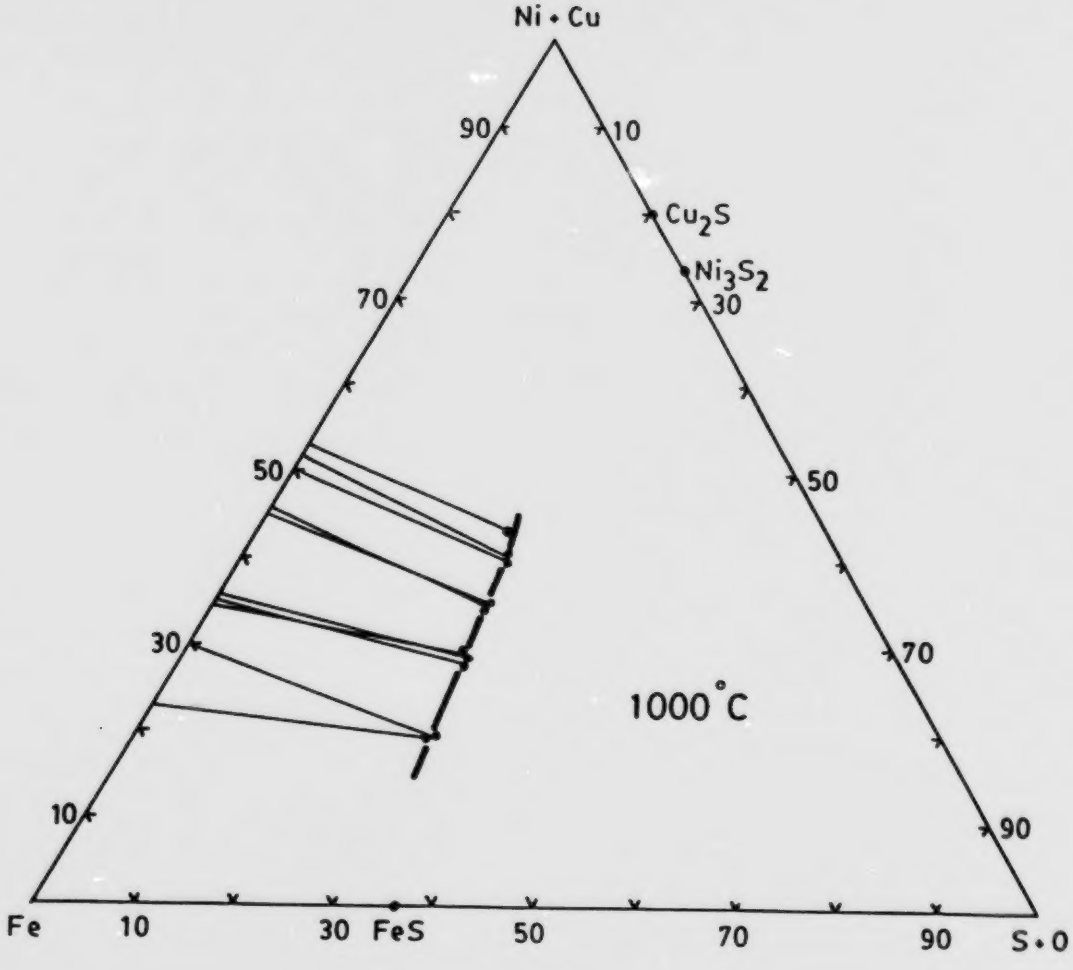


FIGURE 1 - TIE-LINES IN THE LIQUID & ALLOY REGION FOR THE (Ni+Cu)-Fe-S SYSTEM AT 1000°C

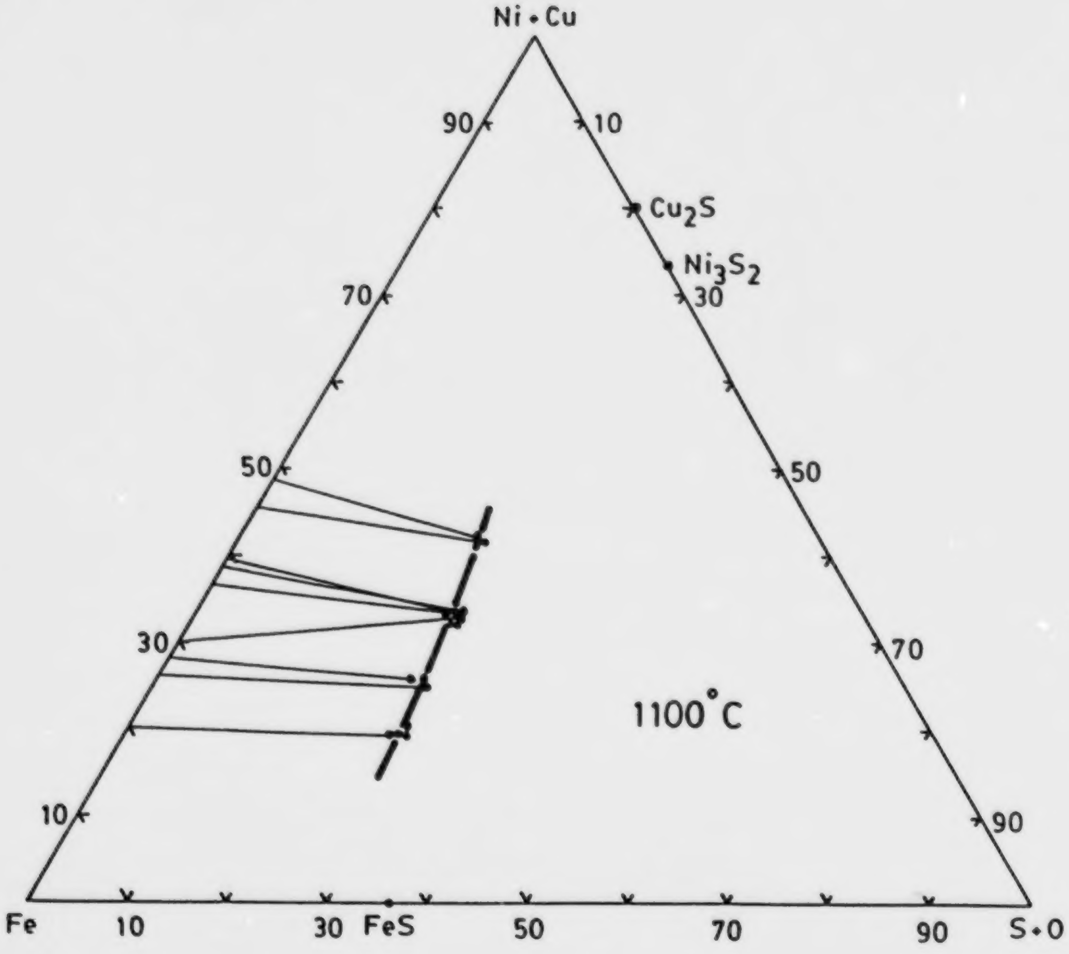


FIGURE 2 - TIE-LINES IN THE LIQUID & ALLOY REGION FOR THE (Ni+Cu)-Fe-S SYSTEM AT 1100°C

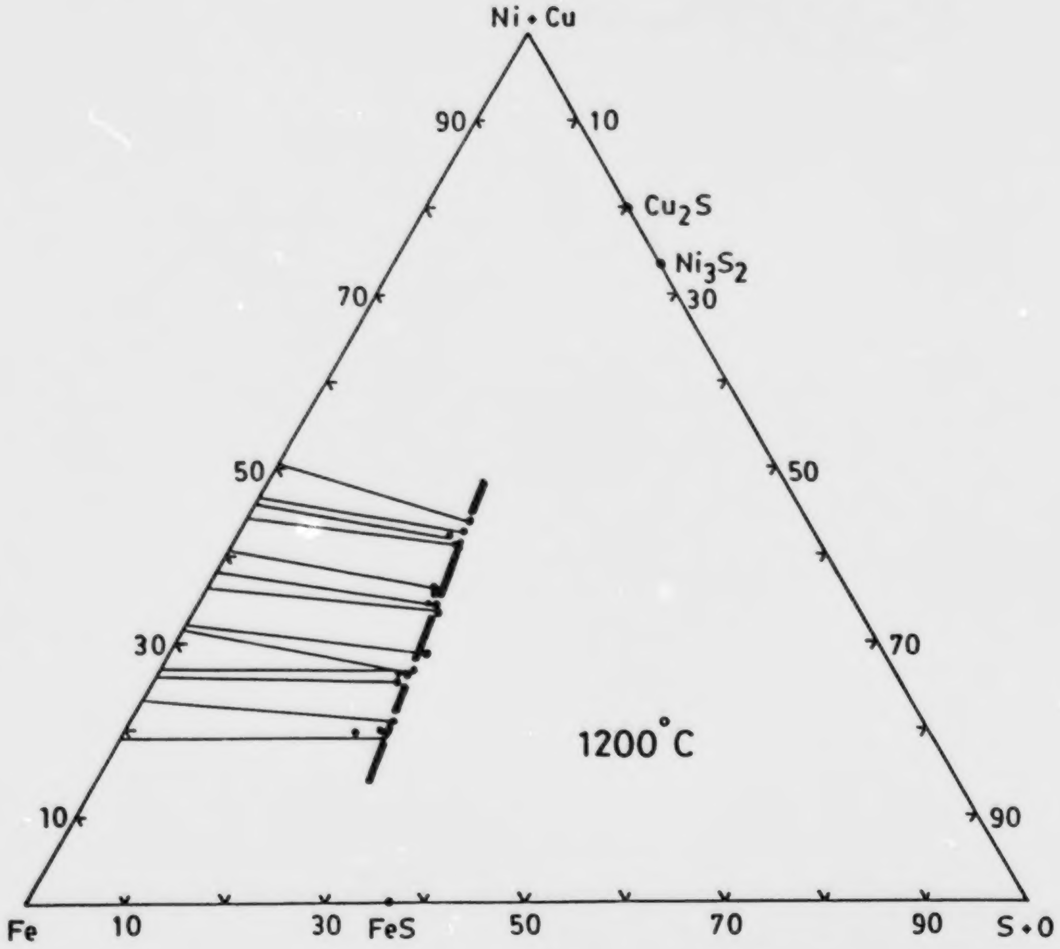


FIGURE 3 - TIE-LINES IN THE LIQUID & ALLOY REGION FOR THE (Ni+Cu)-Fe-S SYSTEM AT 1200°C

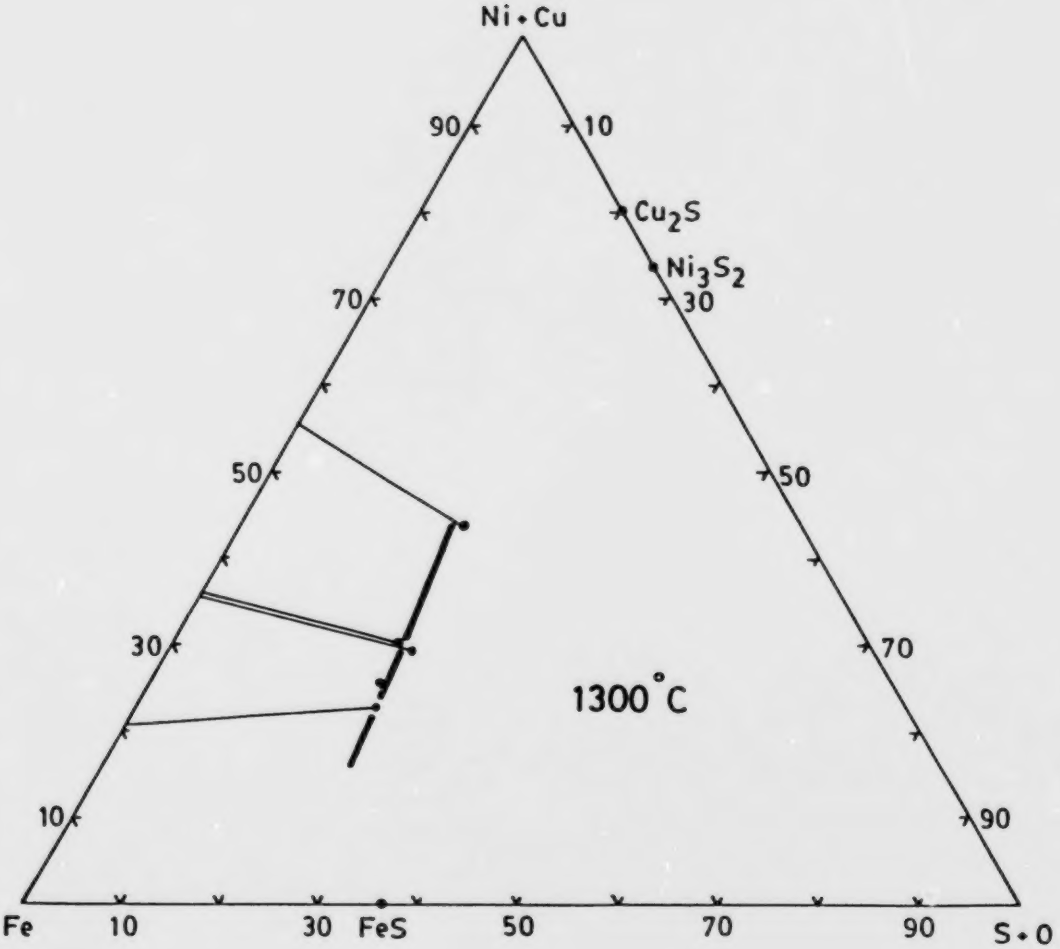


FIGURE 4 - TIE-LINES IN THE LIQUID & ALLOY REGION FOR THE (Ni+Cu)-Fe-S SYSTEM AT 1300°C

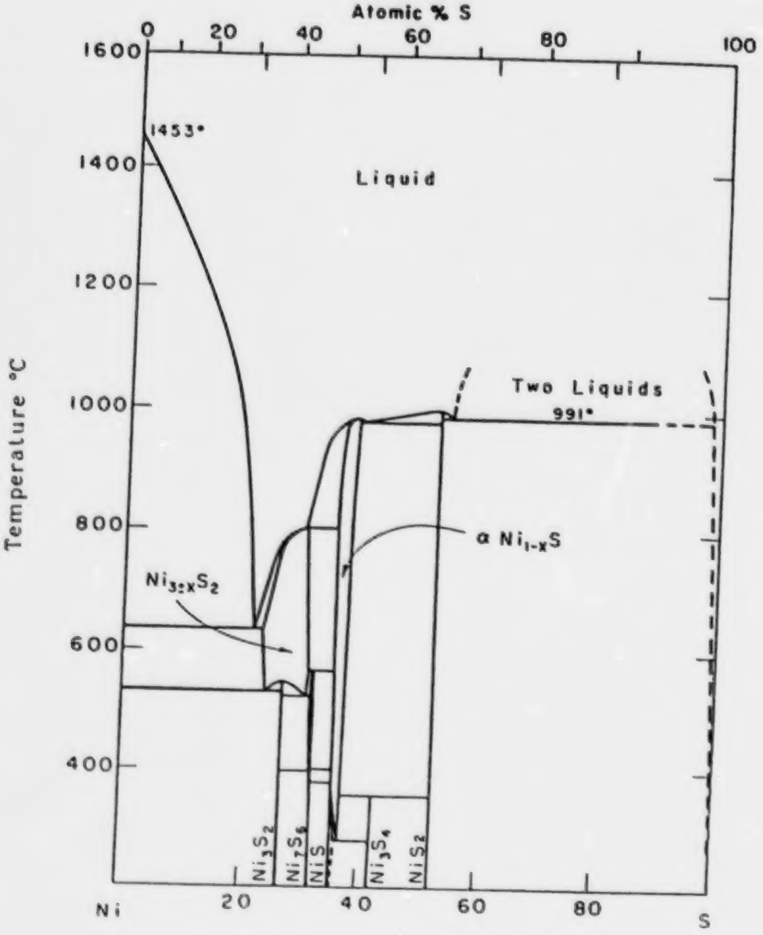


FIGURE 5 - THE Ni-S PHASE DIAGRAM(1)

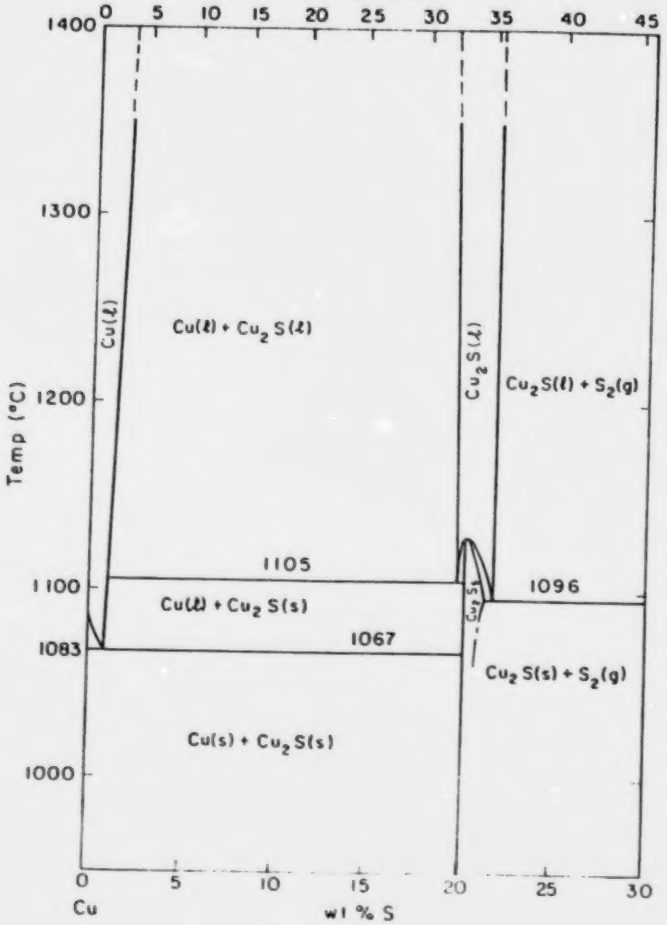


FIGURE 6 - THE Cu-S PHASE DIAGRAM(2)

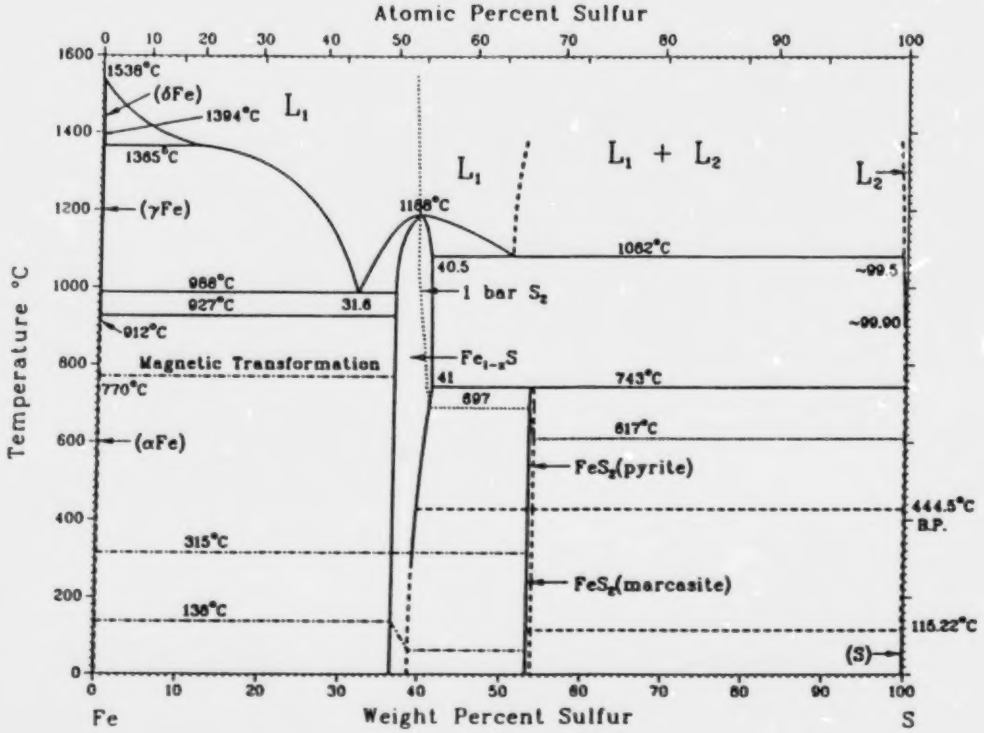


FIGURE 7 - THE Fe-S PHASE DIAGRAM(3)

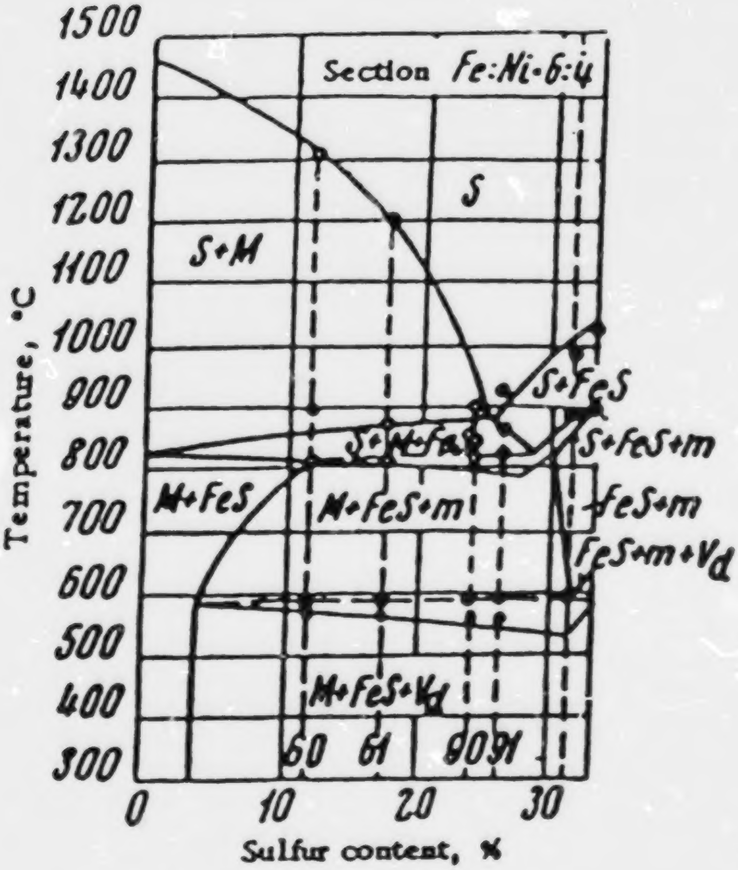


FIGURE 8 - A SECTION OF THE Ni-Fe-S PHASE DIAGRAM (4)

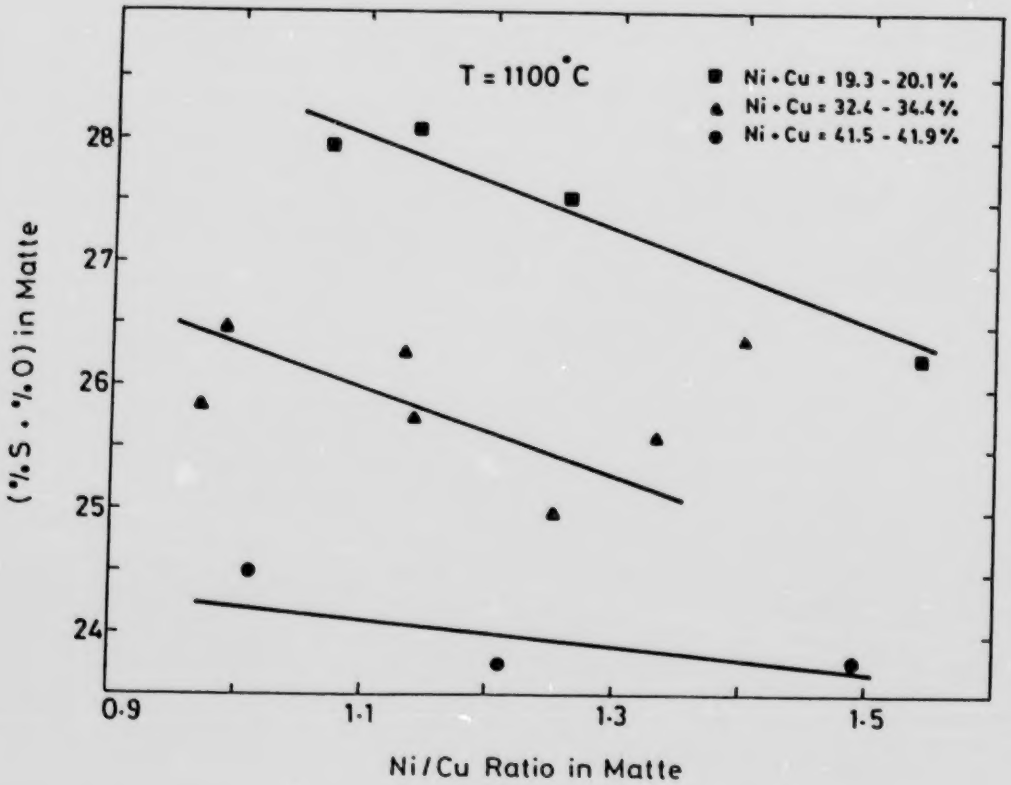


FIGURE 9 - SULPHUR AND OXYGEN CONTENT OF MATTE AS A FUNCTION OF Ni/Cu RATIO

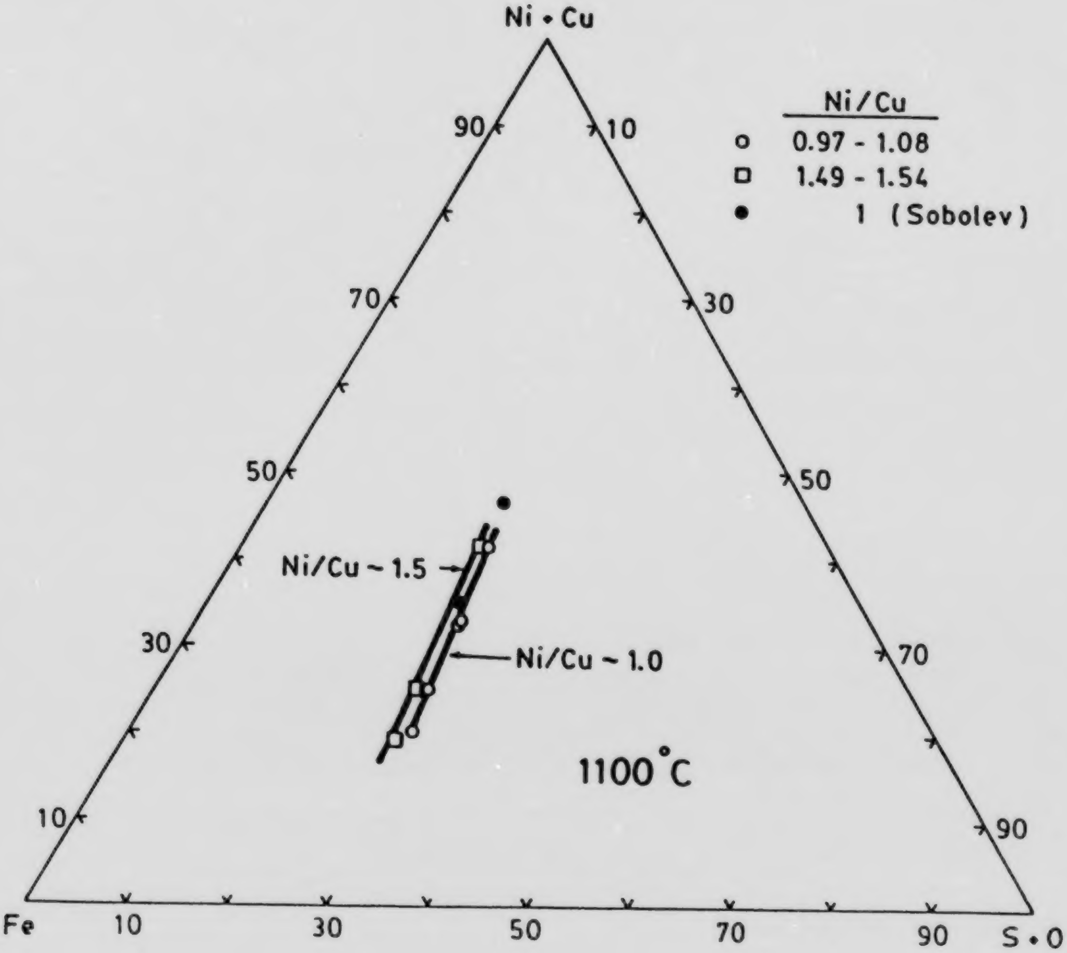


FIGURE 10 - THE EFFECT OF THE Ni/Cu RATIO ON THE MATTE-METAL SATURATION BOUNDARY

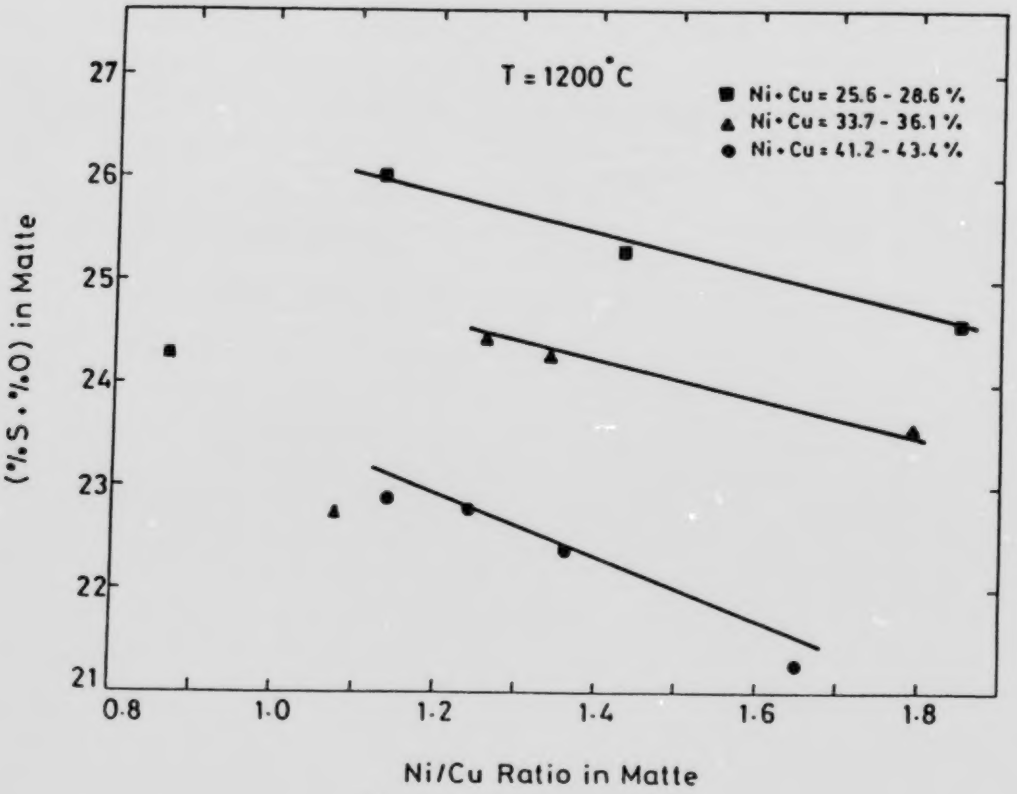


FIGURE 11 - SULPHUR AND OXYGEN CONTENT OF MATTE AS A FUNCTION OF Ni/Cu RATIO (1200°C)

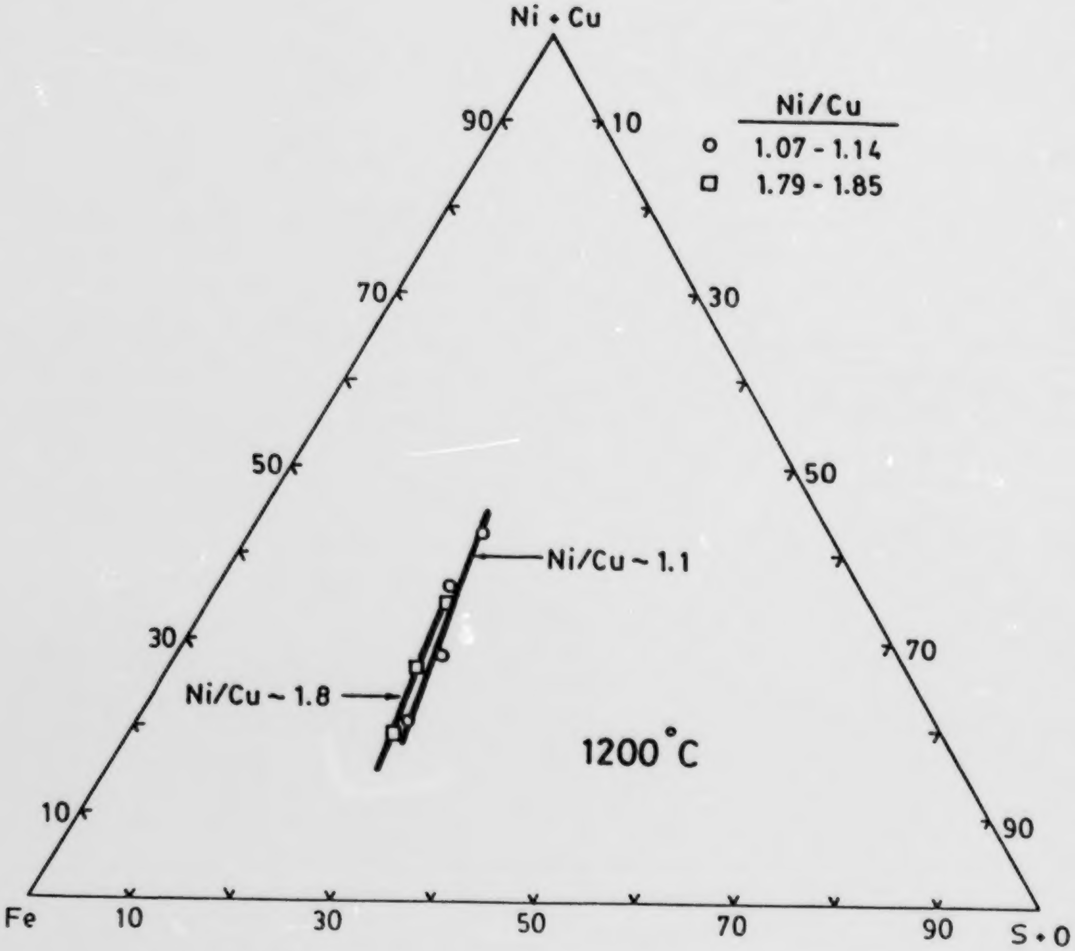


FIGURE 12 - THE EFFECT OF THE Ni/Cu RATIO ON THE MATTE-METAL SATURATION BOUNDARY

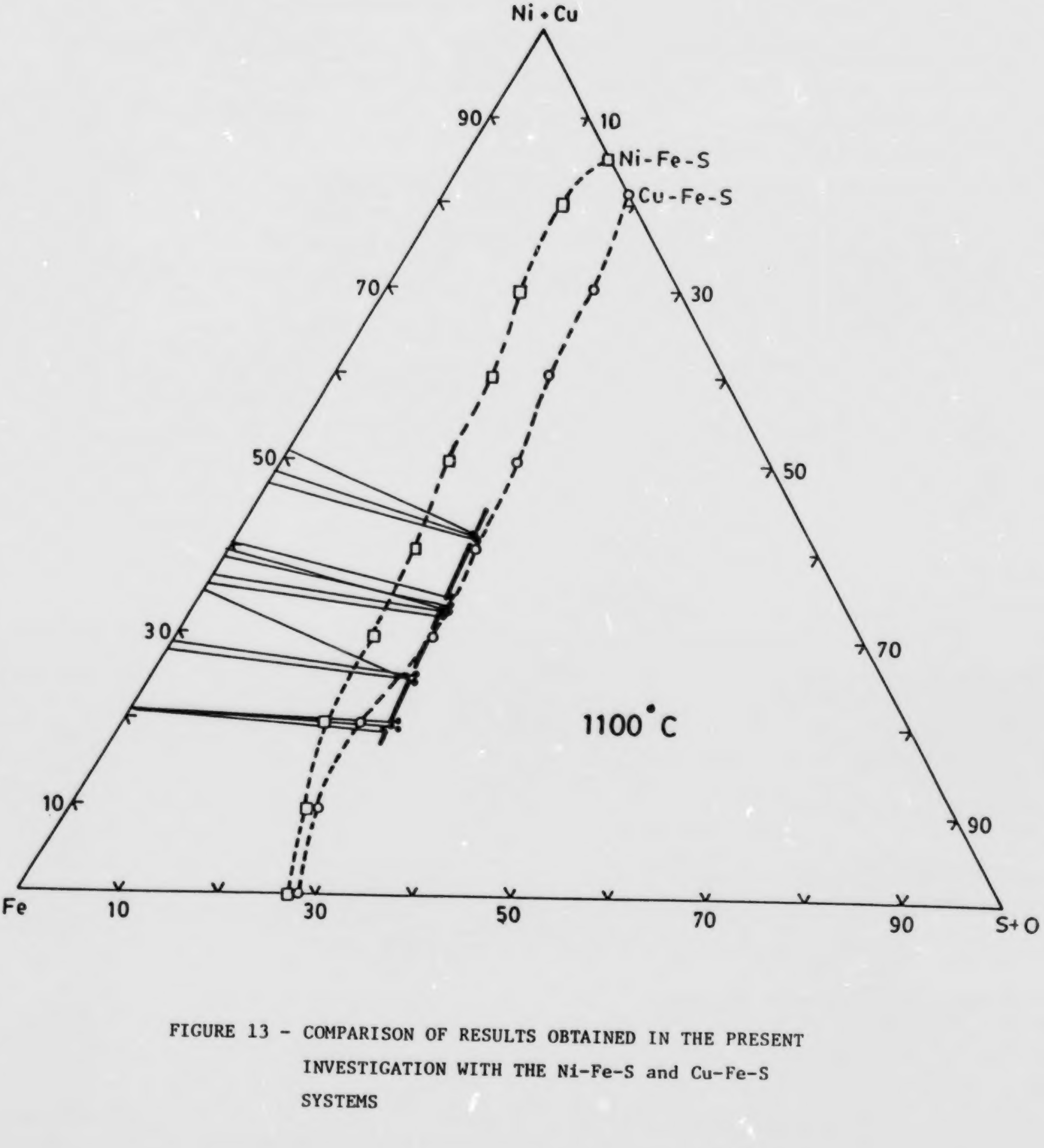


FIGURE 13 - COMPARISON OF RESULTS OBTAINED IN THE PRESENT INVESTIGATION WITH THE Ni-Fe-S and Cu-Fe-S SYSTEMS

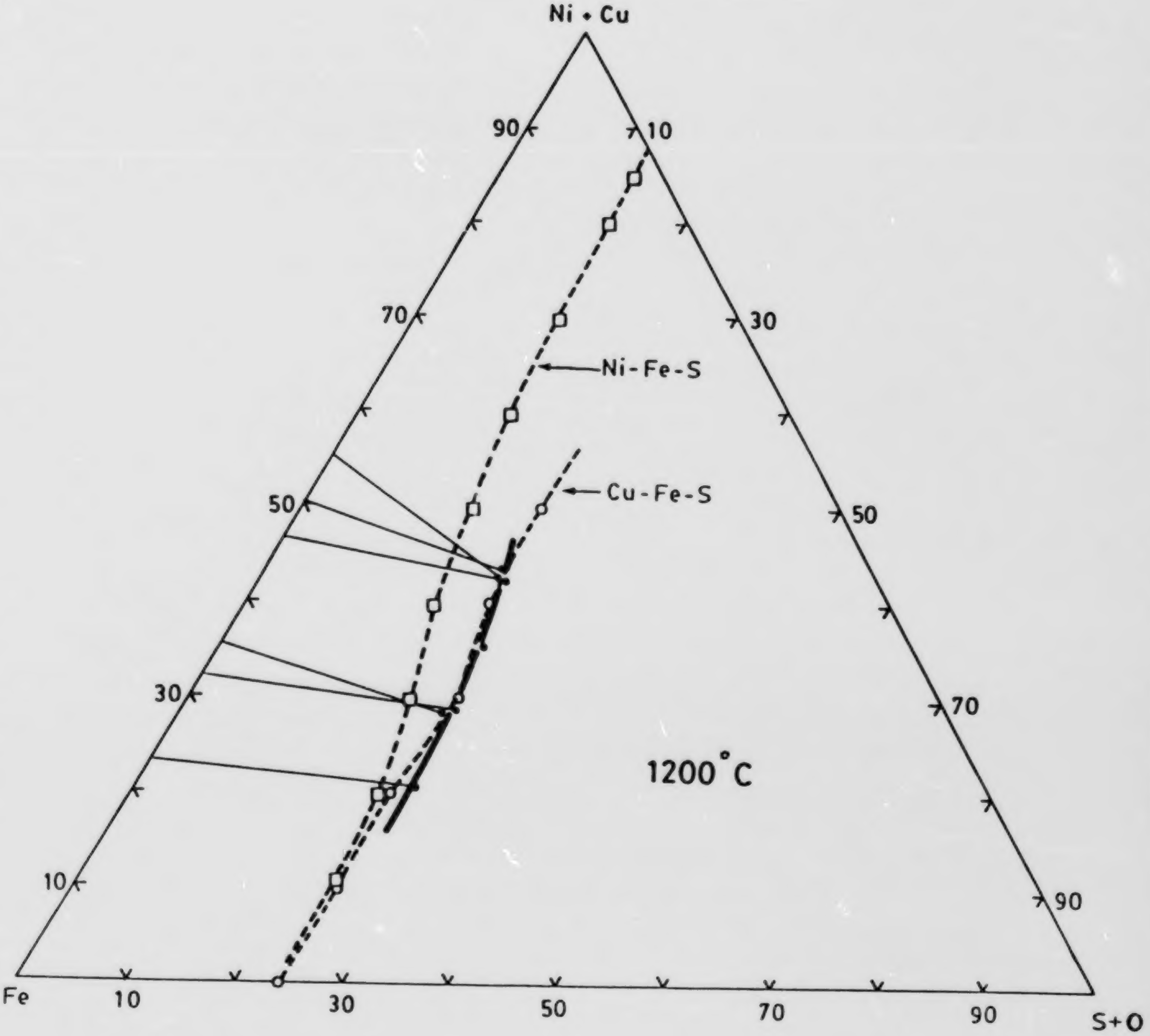
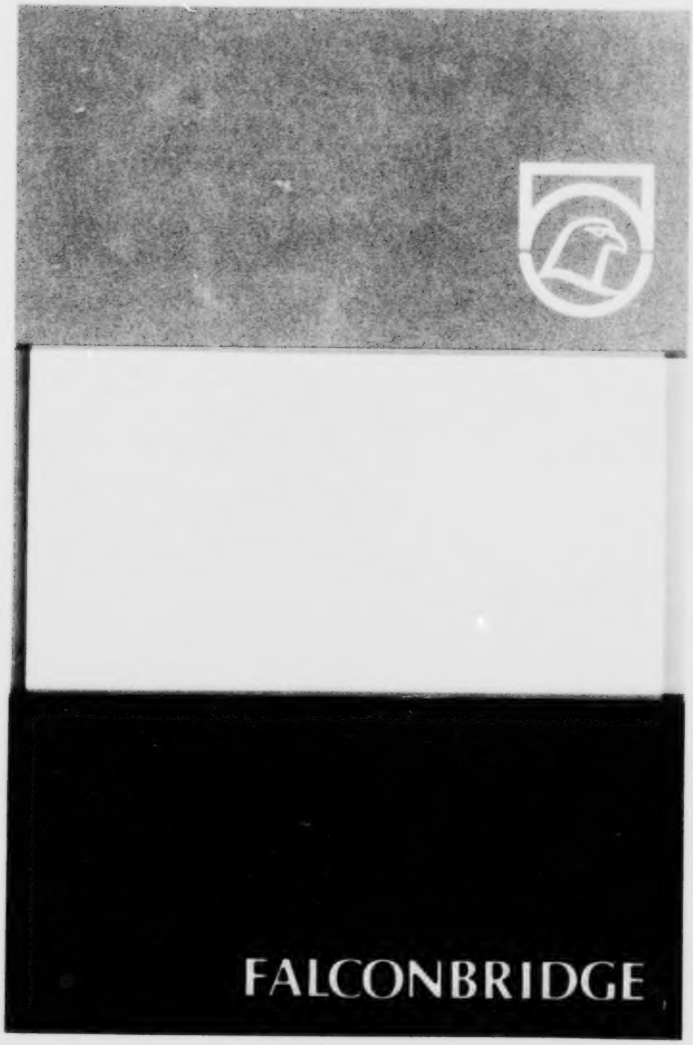


FIGURE 14 - COMPARISON OF RESULTS OBTAINED IN THE PRESENT INVESTIGATION WITH THE Ni-Fe-S and Cu-Fe-S SYSTEMS (1200°C)

Volume

4



FALCONBRIDGE

TO DEVELOP A CLEAN SMELTING PROCESS FOR HIGHLY ROASTED COPPER-NICKEL CALCINES AND TO IMPROVE METAL RECOVERY

PART D:

ELECTRICAL CONDUCTIVITY MEASUREMENTS OF ELECTRIC FURNACE SMELTING SLAGS

by

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H. Tseng and J. M. Toguri (University of Toronto)

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CANMET Scientific Authority: Dr. A. H. Webster

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MICROMEDIA

EXECUTIVE SUMMARY

A laboratory-scale study was initiated in order to yield electrical conductivity data for electric furnace smelting slags. A molybdenum crucible-probe conductivity cell was used for the determinations. Some of the parameters investigated include: temperature, Fe/SiO_2 ratio, lime content, and Fe_2O_3 additions to the slag. Electrical conductivity data are necessary in order to predict the behaviour of electric furnaces as the slag chemistry is altered.

SOMMAIRE

Une étude en laboratoire a été effectuée afin de déterminer les données de la conductivité électrique des scories de fusion dans les fours électriques. Une cellule conductive en forme de creuset-sonde fabriquée de molybdène a été utilisée pour obtenir ces données. Parmis les paramètres étudiés on compte les suivants: le rapport de Fe/SiO_2, la quantité de chaux et les additions de Fe_2O_3 à la scorie. Les données de conductivité électrique son nécessaire afin de prédir le fonctionnement des fours électriques à mesure que change la composition chimique de la scorie.

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APPENDIX II: Calculated Electrical Conductivity Values for all Samples

INTRODUCTION

In order to meet environmental requirements and to cut operating costs, a new smelting process was commissioned for Falconbridge Limited's Sudbury operation in 1978. The current process consists of two fluid bed roasters, two electric furnaces, a converter aisle, and an acid plant. The new operation was designed to remove 50% of the sulphur entering the roasters. In order to reduce SO_2 emissions even further, the smelter has recently increased the degree of roast to 60%. This allows more of the sulphur entering the fluid bed roaster to be fixed as sulphuric acid.

Changes that are made to the roasting operation also affect the operation of the electric furnaces. In this work, the electrical conductivity of smelting slags was examined as a function of temperature, Fe/SiO_2 ratio, lime content, and Fe_2O_3 additions to the slag. Industrially, electrical conductivity data are necessary to predict electric furnace behaviour as the slag chemistry is altered.

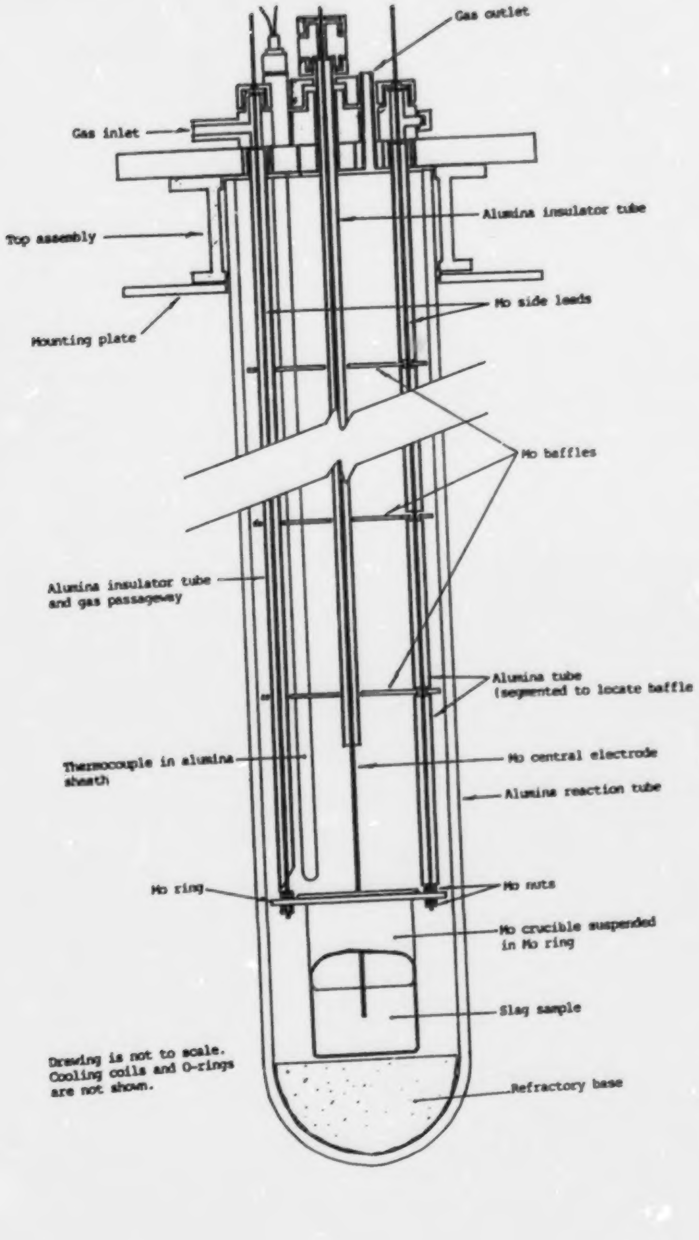
EXPERIMENTAL

Apparatus

The conductivity experiments were performed using an electrode-crucible conductivity cell. A schematic representation of the experimental apparatus is shown in Figure 1. The slag samples were contained in a cylindrically shaped molybdenum crucible (3.81 cm in diameter, 6.5 cm high). The crucible has a lip around its top and it is held in a ring made from molybdenum plate. The ring is suspended by two molybdenum rods from the top of the assembly. These rods serve as electrical contacts for the crucible and are enclosed in alumina tubes.

The crucible serves as one electrode, and a separate molybdenum rod (3 mm diameter) is placed coaxially to the crucible and serves as the central electrode. An alumina tube surrounds the central electrode in order to insulate it from the rest of the assembly. The central electrode is introduced into the cell through the top plate assembly. This arrangement is illustrated in Figure 2. The threaded screw on the elevating mechanism is connected to a digital counter which allows the vertical motion of the electrode to be precisely monitored. One unit on the counter corresponds to 0.127 mm of travel. The temperature of the cell was monitored by a type-R thermocouple located just above the crucible. The top plate is used to mount the various fittings for the central electrode, side leads, gas inlet and outlet, and thermocouple. Rubber O-rings are used to provide gas tight seals for all of the fittings.

A high-temperature tube furnace, heated by molybdenum windings, was used to melt the slag samples. The entire conductivity cell assembly is mounted on a metal frame which can be hydraulically moved, allowing the cell to be moved into or out of the furnace. A simplified view of this arrangement is shown in Figure 3.


Gas outlet
Gas inlet
Alumina insulator tube
Top assembly
Mo side leads
Mounting plate
Mo baffles
Alumina insulator tube and gas passageway
Alumina tube (segmented to locate baffle
Thermocouple in alumina sheath
Mo central electrode
Alumina reaction tube
Mo ring
Mo nuts
Mo crucible suspended in Mo ring
Slag sample
Refractory base

Drawing is not to scale. Cooling coils and O-rings are not shown.

Figure 1: Detail of Conductivity Cell Assembly

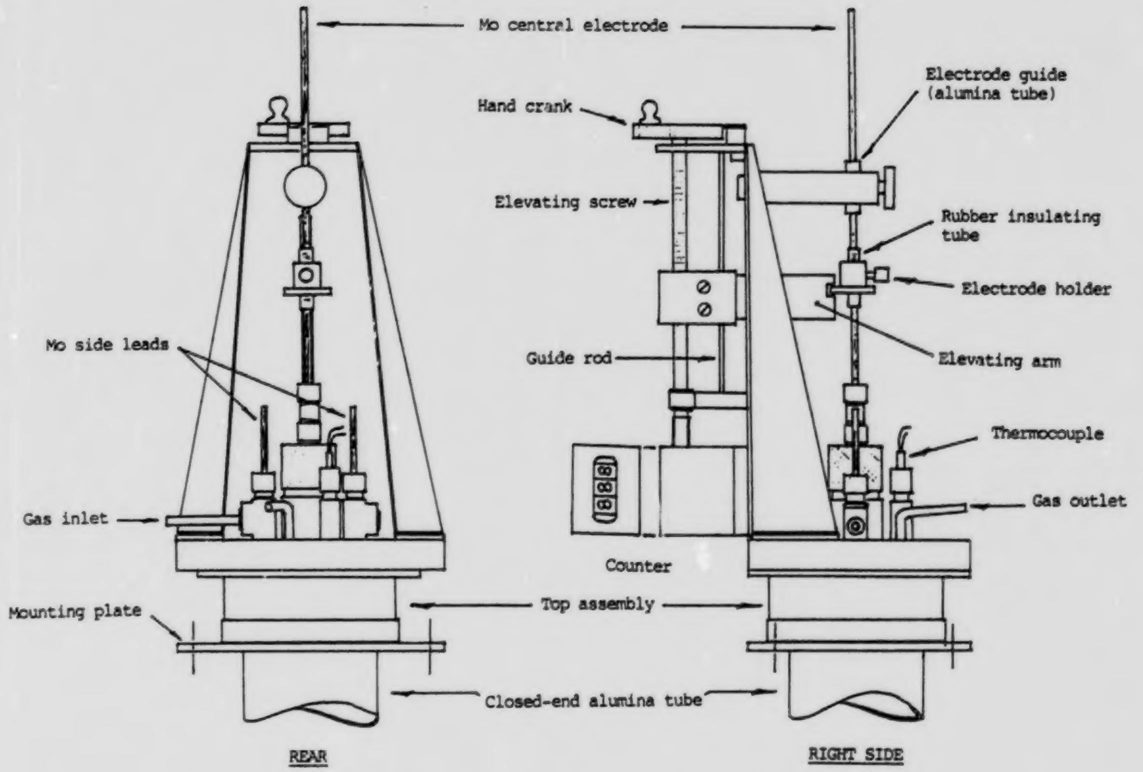

Mo central electrode
Electrode guide (alumina tube)
Hand crank
Elevating screw
Rubber insulating tube
Electrode holder
Mo side leads
Guide rod
Elevating arm
Thermocouple
Gas inlet
Gas outlet
888
Counter
Mounting plate
Top assembly
Closed-end alumina tube
REAR
RIGHT SIDE

Figure 2: Top Assembly Detail. Cooling Coils Have Been Omitted for Clarity.

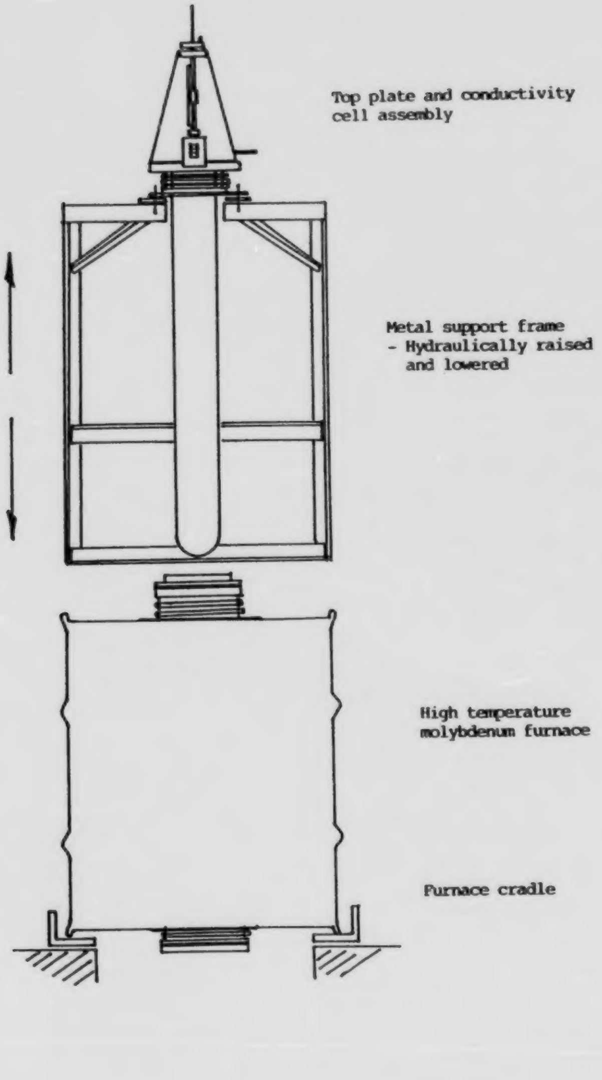

Top plate and conductivity cell assembly
Metal support frame
- Hydraulically raised and lowered
High temperature molybdenum furnace
Furnace cradle

Figure 3: Simplified View of Apparatus Set-Up.

Procedure

The electric furnace slag sample used in this study was obtained from Falconbridge Limited. The analysis of this slag is given in Table 1.

Table 1 (mass %)

S	-	1.08	MgO	-	2.37
Ni	-	0.093	CaO	-	2.35
Cu	-	0.188	Al_2O_3	-	6.20
Co	-	0.087	Fe_3O_4	-	3.00
Fe (total)	-	35.80	SiO_2	-	37.55

The Fe/SiO_2 ratio of the 'as-received' slag is 0.95. This ratio was decreased by adding silica and increased by the addition of FeO (using mixtures of hematite and iron powder). The additions were dried, and then intimately mixed with the 'as-received' slag before being loaded into the conductivity cell.

A sample mass of approximately 100 g was used in all conductivity experiments. This produced a melt depth of approximately 3.0 cm. The samples were not pre-melted (i.e. all melting took place during the actual experiments).

The slag sample was placed in a Mo crucible which was then loaded into the conductivity cell. A closed-end alumina tube was placed over the assembly and sealed to the top plate. The entire assembly was mounted onto the support frame and the water cooling and gas tubes were connected. The atmosphere inside of the cell was flushed with gettered high-purity argon gas. Next, the closed-end alumina tube was slowly lowered into the furnace by hydraulically lowering the support frame. Since the furnace was always kept at a relatively high temperature (>850°C), it was necessary to lower the tube extremely slowly to prevent it from cracking. The lowering operation normally took between two and three hours. Once the conductivity cell was completely in the furnace hot-zone, the furnace temperature was increased to the desired level. The samples were allowed to stabilize at the desired temperature for at least one hour before mesurements were taken. All experiments were performed at either 1250 or 1300°C.

A Hewlett Packard model 4328A milliohmeter was used for the resistance measurements. This device provides a 1 kc/s alternating current to prevent polarization at the electrodes. Due to the nature of the experimental apparatus, it was necessary to shut off all power to the furnace in order to obtain reliable resistance readings. With the power off, the central electrode was lowered until the surface of the melt was electrically identified (i.e. when the meter registered contact with the surface). Resistance measurements were taken at predetermined levels in the slag, stopping to reheat the sample whenever the cell temperature started to cool significantly. Measurements were taken until the bottom of the crucible was contacted. The contact resistance was noted as was the depth of the sample.

Measurements were only taken with the electrode lowered into the melt. When the electrode was raised, it tended to pull some slag with it. This resulted in erroneous measurements, especially near the surface of the melt.

Measurements were repeated three times at each of the two temperatures. After the experiment, the furnace temperature was lowered to its usual holding temperature and the cell was slowly raised out of the furnace. When the cell had cooled, the crucible containing the slag sample was removed and its change in mass was recorded. The sample was then sent to Falconbridge for chemical analysis.

EXPERIMENTAL RESULTS AND DISCUSSION

The conductivity of a melt can be calculated using the following equation:

$$\text{Specific Electrical Conductance} = \frac{K}{R-r} \qquad (1)$$

where:

K = the cell constant at a given electrode immersion level (cm^{-1})

R = the total resistance measured at the same level (ohm)

r = the external resistance of the system, including electrodes, contacts and leads (ohm).

The cell constant of the experimental apparatus was determined using a 1 N KCl solution at room temperature. A plot of the cell constant versus depth is shown in Figure 4.

The resistance measurements for each of the slag samples during the various experimental runs are tabulated in Appendix I. Ideally, for a given sample at a given temperature, the conductivities calculated from the measured resistance values at the various depths should be equal. From the results, however, there appears to be some variation of conductivity with depth. In most of the runs, the calculated conductivity values seem significantly lower towards the top of the melt. This can be attributed to a temperature gradient that exists within the sample. After extensive temperature profile tests, it was discovered that the temperature profile of the furnace was less than ideal. The use of a

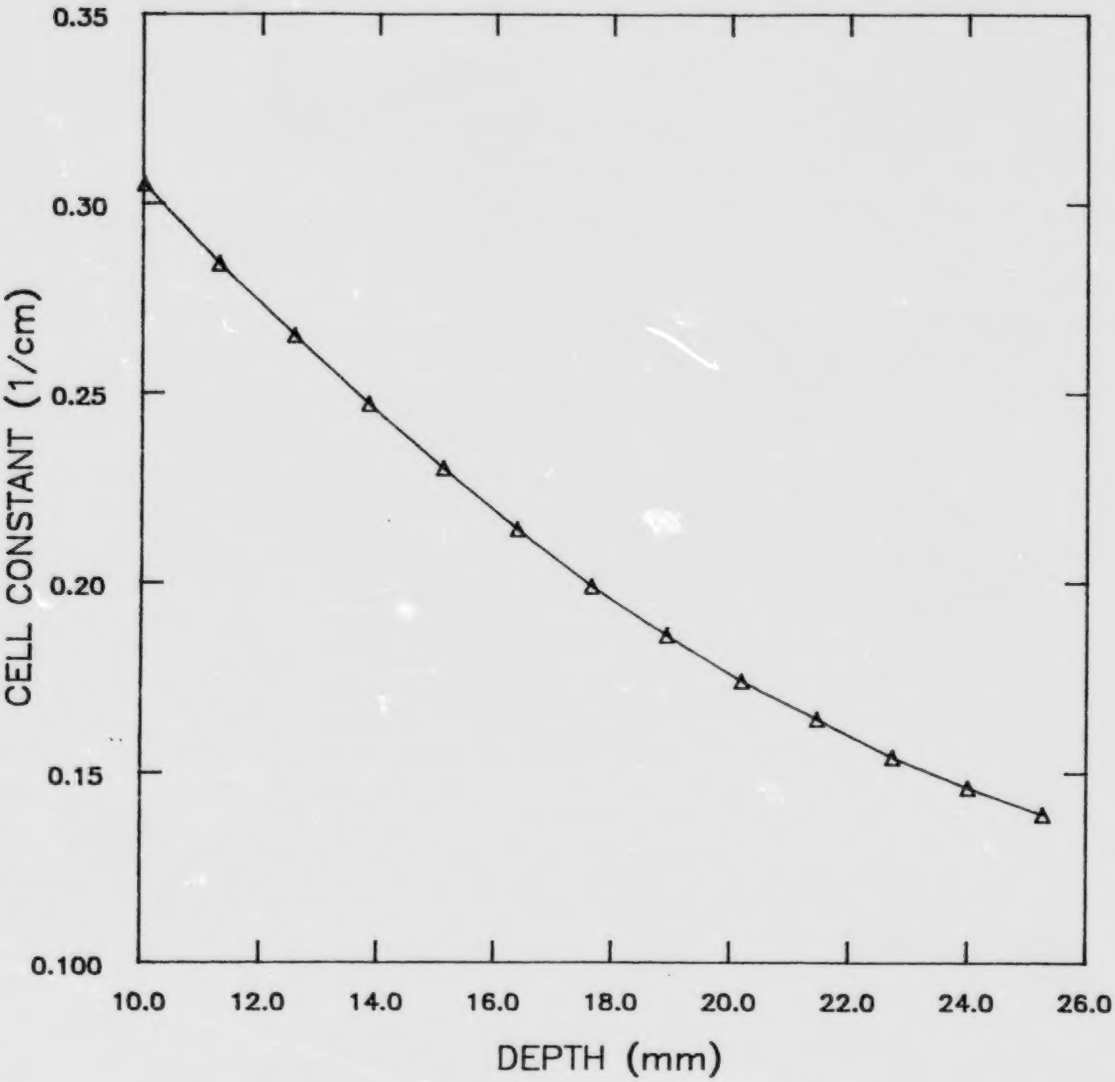


Figure 4: Cell Constant Calibration Curve

molybdenum lid over the crucible decreased the vertical temperature gradient to an acceptable level. The temperature indicated by the monitoring thermocouple in the conductivity cell was found to be lower than the actual temperature within the crucible. Tests were performed to determine the indicated temperature that corresponded to the desired temperature within the melt. The desired temperature was located near the middle of the slag sample.

The mean and standard deviation of the calculated conductivity values were determined. Two approaches were employed. In the first one, a 'wide' range of data (i.e. all calculated points excluding the two extremes) were considered for the statistical analysis. In the second case, a 'narrow' range (i.e. points withing a 5 mm range around the level of the desired temperature) were considered.

Values determined from the 'narrow' range population should be considered to be more accurate than those from the 'wide' range. The mean and standard deviation values for each run are tabulated in Appendix II. It is interesting to note that there seems to be more deviation for samples containing high levels of iron.

Every attempt was made to ensure that conditions were consistent for duplicate runs. Errors in indentifying the surface of the slag, reading the meter, and slight differences in temperature may account for some of the variations in the calculated conductivity values. With the monitoring thermocouple located outside of the crucible, and due to differences in heating and cooling rates inside and outside of the melt, the actual melt temperature could not be accurately determined when the power was switched on and off in order to take resistance readings. The temperature within the cell usually remained stable for a long enough time to complete the resistance measurements while the power was off. In reheating the melt for subsequent runs, however, it is possible that some resistance measurements were taken before the temperature was at the desired level. Wherever possible, any irregularities in the runs were identified and considered when comparing data between various runs. Runs that varied significantly from the others were disregarded.

After the conductivity experiments were completed, the slags were shipped to Falconbridge and analyzed for Fe (total), SiO_2, and CaO. The results are summarized in Table 2.

The effects of temperature, Fe/SiO_2 ratio, and oxygen content on the electrical conductivity of the slag are shown in Figure 5. A linear relationship was assumed for each of the test conditions due to the limited number of data points available. From these results, it is apparent that increases in temperature, Fe content, or oxygen content all increase the electrical conductivity of the slag. It should be noted that the addition of hematite to increase the oxygen content of the slag also increased the iron content, resulting in the lines for these additions to be shifted to the right. The values used in Figure 5 are indicted by asterisks in Appendix II.

TABLE 2 ANALYSIS OF SLAG SAMPLES

SLAG SAMPLE (TARGET)	Fe/SiO_2 *	CaO (mass %) *
0.85 Fe/SiO_2	0.843	2.04
0.85 Fe/SiO_2 + 5% Fe_2O_3	0.937	2.01
0.95 Fe/SiO_2	0.940	2.22
0.95 Fe/SiO_2 +5% Fe_2O_3	1.029	2.12
1.029 Fe/SiO_2	1.015	2.20
1.029 Fe/SiO_2 +5% Fe_2O_3	1.099	2.12
0.85 Fe/SiO_2 +7% CaO	0.838	6.00
0.85 Fe/SiO_2 +10% CaO	0.843	8.30
0.85 Fe/SiO_2 +15% CaO	0.845	10.70

*Based on Chemical Analyses

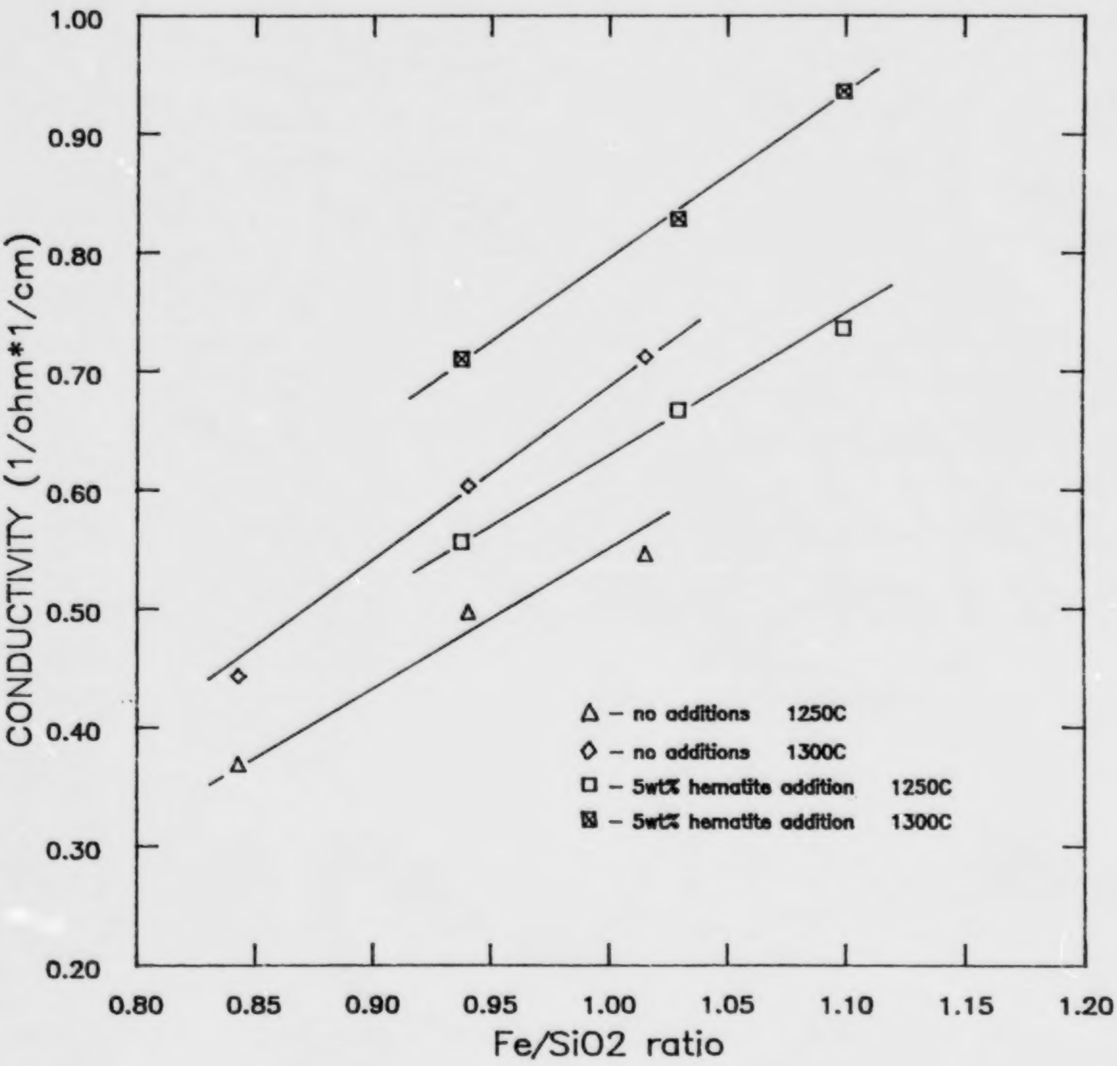


Figure 5: Effect of Fe/SiO$_2$ Ratio and Hematite Addition on Electrical Conductivity

Figure 6 shows the effect of CaO additions on the conductivity of the slag. The conductivity values were plotted against the total CaO content of the sample based on its final chemical analysis. From Figure 6, it appears that the addition of CaO additions increase the electrical conductivity of the slag. Due to the limited number of data points, a linear relationship was assumed. More experiments need to be performed to determine if the curves level off with higher CaO additions. Mori and Matsushita have found that the electrical conductivity in the binary $CaO-SiO_2$ system levels off with high CaO additions.

After the tests several slag samples were analyzed for their molybdenum content. The slags contained between 0.2 and 0.7% Mo. These levels are similar to those obtained by Victorovich et al. It is unlikely that these low levels will significantly influence the results obtained in this investigation.

Experiments to determine the silica saturation boundary of the slag could not be performed due to the limitations of the apparatus. Since the thermocouple was located outside of the sample, it was difficult to determine the actual melt temperature as the furnace was cooling.

SUMMARY

The results of these experiments indicate that increases in temperature, iron content, oxygen potential, and CaO additions all tend to increase the electrical conductivity of the slag.

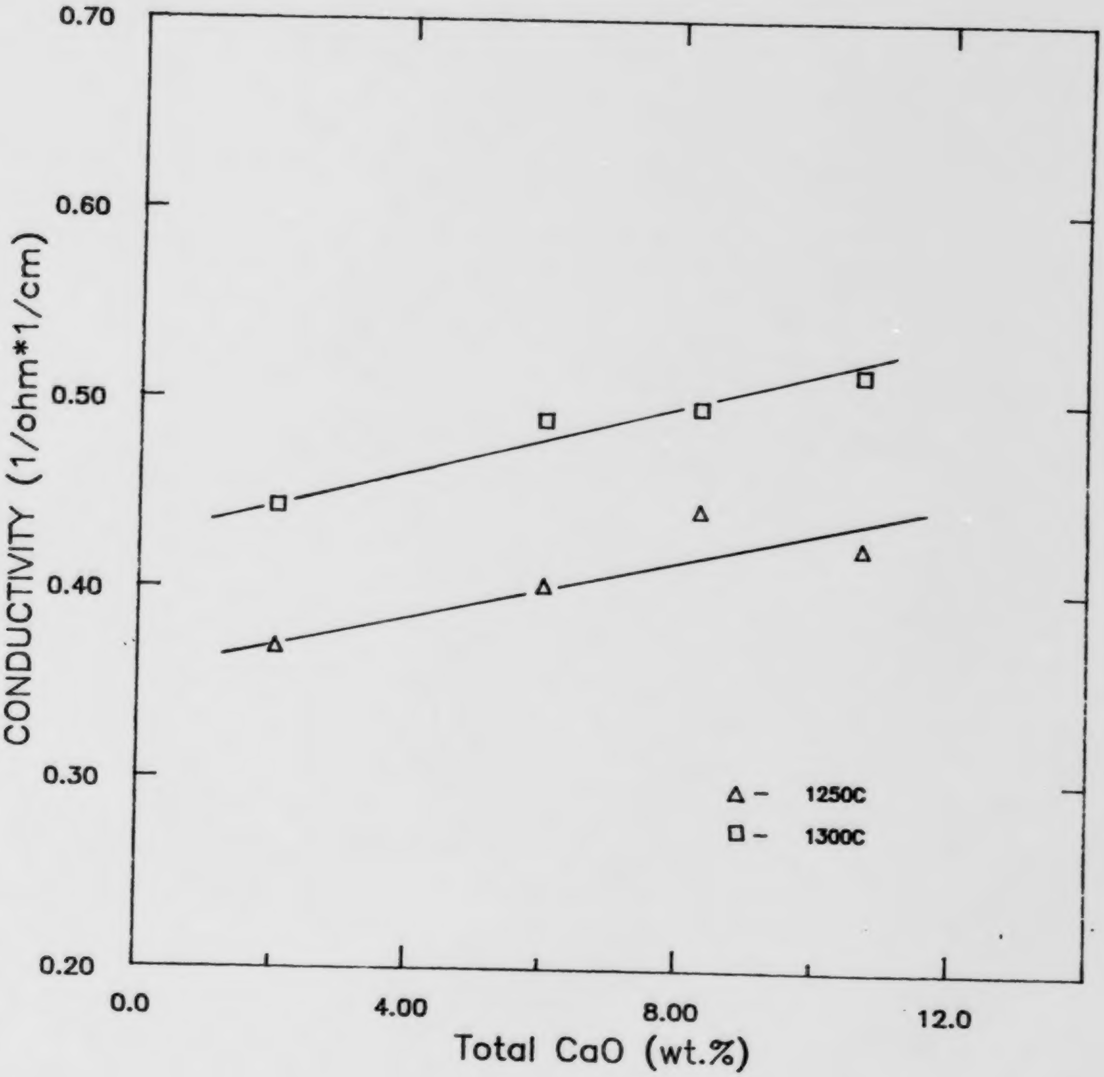


Figure 6: Effect of CaO Additions on Electrical Conductivity

REFERENCES

1. G. S. Victorovich, C. Diaz, and D. K. Vallbacka: "Electrical Conductivity of Ferromagnesian Silicates", in Second International Symposium on Metallurgical Slags and Fluxes (H. A. Fine and D. R. Gaskell, eds.), TMS-AIME, 1984, pp 907-924.

2. K. Mori and Y. Matsushita: "The Electrical Conductivity of Molten Binary Slags" Tetsu-to-Hagane, Volume 38(5), 1952, pp 6-11.

APPENDIX I

DATA FOR ELECTRICAL CONDUCTIVITY MEASUREMENTS

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2

DATE: DEC. 3/87

Additions made to sample:

4.57 g SiO_2 to 100 g as-received slag

Atm.: High purity Ar (gettered).

Total wt. of sample: 104.57 g

Total wt. w/crucible: init.- 151.50 g
finl.- 151.44 g

RUN#: 1

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	122	0.0	5.7 ~~[illegible]~~
3	83	4.95	1.8
3	63	7.49	1.3
3	43	10.03	1.0
1	33	11.3	0.91
1	23	12.57	0.84
1	13	13.84	0.76
1	03	15.11	0.70
1	993	16.38	0.66
1	983	17.65	0.61
1	973	18.92	0.58
1	963	20.19	0.54
1	953	21.46	0.51
1	943	22.73	0.48
1	933	24.0	0.45
1	923	25.27	0.43
1	913	26.54	0.39
1	903	27.81	0.345
1 —	893 —	29.08 —	0.06 — BOTTOM —
	DEPTH. —	29.0 mm	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 3/87

SLAG SAMPLE: 0.85 Fe/SiO_2

Atm.: H.P. Ar

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω

RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	5.7	—
4.95	—	1.8	—
7.49	—	1.3	—
10.03	0.305	1.0	0.324
11.3	0.284	0.91	0.334
12.57	0.265	0.84	0.340
13.84	0.247	0.76	0.353
15.11	0.230	0.70	0.359
16.38	0.214	0.66	0.357
17.65	0.199	0.61	0.362
18.92	0.186	0.58	0.358
20.19	0.174	0.54	0.363
21.46	0.164	0.51	0.364
22.73	0.154	0.48	0.367
24.0	0.146	0.45	0.374
25.27	0.139	0.43	0.376
26.54	—	0.39	—
27.81	—	0.345	—
29.08	—	—	—

wide – 0.357 ± 0.012

narrow – 0.358 ± 0.003

X

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2

DATE: DEC. 3/87

Additions made to sample:

4.57 g SiO_2 to 100 g as-received slag

Atm.: High purity Ar (gettered)

Total wt. of sample: 104.57

Total wt. w/crucible: init.- 151.50 g

finl.- 151.44 g

RUN#: 2

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	122	0.0	4.7
3	83	4.95	1.6
3	63	7.49	1.2
1	43	10.03	0.95
1	33	11.3	0.86
1	23	12.57	0.80
1	13	13.84	0.74
1	03	15.11	0.69
1	993	16.38	0.64
1	983	17.65	0.60
1	973	18.92	0.56
1	963	20.19	0.52
1	953	21.46	0.50
1	943	22.73	0.46
1	933	24.0	0.44
1	923	25.27	0.41
1	913	26.54	0.38
1	903	27.81	0.32
1	893	29.08	0.06 – BOTTOM
		Depth – 29.0 mm	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 3/87

SLAG SAMPLE: 0.85 Fe/SiO_2

Atm.: H.P.Ar

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω

RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	4.7	—
4.95	—	1.6	—
7.49	—	1.2	—
10.03	0.305	0.95	0.343
11.3	0.284	0.86	0.355
12.57	0.265	0.80	0.358
13.84	0.247	0.74	0.363
15.11	0.230	0.69	0.365
16.38	0.214	0.64	0.369
17.65	0.199	0.60	0.369
18.92	0.186	0.56	0.372
20.19	0.174	0.52	0.378
21.46	0.164	0.50	0.373
22.73	0.154	0.46	0.385
24.0	0.146	0.44	0.384
25.27	0.139	0.41	0.397
26.54	—	0.38	—
27.81	—	0.32	—
29.08	—	—	—

wide – 0.370 ± 0.010

narrow – 0.368 ± 0.004

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2

DATE: DEC. 3/87

Additions made to sample:

4.57 g SiO_2 to 100 g as-received slag

Atm.: High purity Ar (gettered)

Total wt. of sample: 104.57g

Total wt. w/crucible: init.- 151.50g
finl.- 151.44g

RUN#: 3

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	122	0.0	5.2
3	83	4.95	1.6
3	63	7.49	1.2
1	43	10.03	0.96
1	33	11.3	0.86
1	23	12.57	0.80
1	13	13.84	0.73
1	03	15.11	0.68
1	993	16.38	0.64
1	983	17.65	0.59
1	973	18.92	0.56
1	963	20.19	0.53
1	953	21.46	0.49
1	943	22.73	0.47
1	933	24.0	0.44
1	923	25.27	0.~~3~~41
1	913	26.54	0.38
1	903	27.81	0.33
1	893	29.08	0.06 – BOTTOM
		Depth = 29.0 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 3/07.

SLAG SAMPLE: 0.85 Fe/SiO_2

Atm.: H.P. Ar

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω

RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	5.2	—
4.95	—	1.6	—
7.49	—	1.2	—
10.03	0.305	0.96	0.339
11.3	0.284	0.86	0.355
12.57	0.265	0.80	0.358
13.84	0.247	0.73	0.369
15.11	0.230	0.68	0.371
16.38	0.214	0.64	0.369
17.65	0.199	0.59	0.375
18.92	0.186	0.56	0.372
20.19	0.174	0.53	0.370
21.46	0.164	0.49	0.381
22.73	0.154	0.47	0.376
24.0	0.146	0.44	0.384
25.27	0.139	0.41	0.397
26.54	—	0.38	—
27.81	—	0.33	—
29.08	—	—	—

wide – 0.371 ± 0.009

narrow – 0.371 ± 0.002

SLAG CONDUCTIVITY DETERMINATION

SUMMARY OF RESISTANCE MEASUREMENTS:

DATE: DEC. 3/87

Atm.: H.P. Ar

SLAG SAMPLE: 0.85 Fe/SiO_2

TEMPERATURE: 1250°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG. (#2+3).
	RUN# 1	RUN# 2	RUN# 3	
0.0	5.7	4.7	5.2	4.95
4.95	1.8	1.6	1.6	1.60
7.49	1.3	1.2	1.2	1.20
10.03	1.0	0.95	0.96	0.955
11.3	0.91	0.86	0.86	0.877
12.57	0.84	0.80	0.80	0.800
13.84	0.78	0.74	0.73	0.735
15.11	0.70	0.69	0.68	0.685
16.38	0.66	0.64	0.64	0.640
17.65	0.61	0.60	0.59	0.595
18.92	0.58	0.56	0.56	0.560
20.19	0.54	0.52	0.53	0.525
21.46	0.51	0.50	0.49	0.495
22.73	0.48	0.46	0.47	0.465
24.0	0.45	0.44	0.44	0.440
25.27	0.43	0.41	0.41	0.410
26.54	0.39	0.38	0.38	0.380
27.81	0.345	0.32	0.33	0.325
29.08 —	0.06 —	0.06 —	0.06 —	0.06 R_{ext}.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 3/87

SLAG SAMPLE: 0.85 Fe/SiO_2

Atm.: HP. Ar.

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (#2+3)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	4.95	—
4.95	—	1.60	—
7.49	—	1.20	—
10.03	0.305	0.955	0.341
11.3	0.284	0.877	0.348
12.57	0.265	0.800	0.358
13.84	0.247	0.735	0.366
15.11	0.230	0.685	0.368
16.38	0.214	0.640	0.369
17.65	0.199	0.595	0.372
18.92	0.186	0.560	0.372
20.19	0.174	0.525	0.374
21.46	0.164	0.495	0.377
22.73	0.154	0.465	0.380
24.0	0.146	0.440	0.384
25.27	0.139	0.410	0.397.
26.54	—	0.380	—
27.81	—	0.325	—
29.08	—	—	—

wide - 0.370 ± 0.010

narrow - 0.369 ± 0.003

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 3/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar

SLAG SAMPLE: 0.85 Fe/SiO_2

TEMPERATURE: 1250°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	5.7	4.7	5.2	5.2
4.95	1.8	1.6	1.6	1.67
7.49	1.3	1.2	1.2	1.23
10.03	1.0	0.95	0.96	0.970
11.3	0.91	0.86	0.86	0.877
12.57	0.84	0.80	0.80	0.813
13.84	0.76	0.74	0.73	0.743
15.11	0.70	0.69	0.68	0.690
16.38	0.66	0.64	0.64	0.647
17.65	0.61	0.60	0.59	0.600
18.92	0.58	0.56	0.56	0.567
20.19	0.54	0.52	0.53	0.530
21.46	0.51	0.50	0.49	0.500
22.73	0.48	0.46	0.47	0.470
24.0	0.45	0.44	0.44	0.443
25.27	0.43	0.41	0.41	0.417
26.54	0.39	0.38	0.38	0.383
27.81	0.345	0.32	0.33	0.332
29.08 —	— 0.06 —	— 0.06 —	— 0.06 —	— 0.06 Rext.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 3/87

SLAG SAMPLE: 0.85 Fe/SiO_2

Atm.: H.P. Ar.

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	5.2	—
4.95	—	1.67	—
7.49	—	1.23	—
10.03	0.305	0.970	0.335
11.3	0.284	0.877	0.348
12.57	0.265	0.813	0.352
13.84	0.247	0.743	0.362
15.11	0.230	0.690	0.365
16.38	0.214	0.647	0.365
17.65	0.199	0.600	0.369
18.92	0.186	0.567	0.367
20.19	0.174	0.530	0.370
21.46	0.164	0.500	0.373
22.73	0.154	0.470	0.376
24.0	0.146	0.443	0.381
25.27	0.139	0.417	0.389
26.54	—	0.383	—
27.81	—	0.332	—
29.08	—	—	—

wide – 0.366 ± 0.010

narrow – 0.366 ± 0.003

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2

DATE: DEC. 3/87

Additions made to sample:

4.57 g SiO_2 to 100 g as-received slag.

Atm.: High purity Ar (gettered)

Total wt. of sample: 104.57 g

Total wt. w/crucible: init.- 151.50 g

finl.- 151.44 g

RUN#: 1

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	121	0.0	3.5
3	82	4.95	1.45
3	62	7.49	1.05
1	42	10.03	0.84
1	32	11.3	0.76
1	22	12.57	0.70
1	12	13.84	0.64
1	02	15.11	0.60
1	992	16.38	0.56
1	982	17.65	0.52
1	972	18.92	0.47
1	962	20.19	0.45
1	952	21.46	0.425
1	942	22.73	0.40
1	932	24.0	0.38
1	922	25.27	0.355
1	912	26.54	0.33
1	902	27.81	0.28
1	892	29.08	0.06 – BOTTOM
		Depth. = 29.0 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 0.85 Fe/SiO_2

TEMPERATURE: 1300°C ± 5°

DATE: DEC. 3/87

Atm.: H.P. Ar.

$r_{ext.}$ = 0.06 Ω

RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	3.5	—
4.95	—	1.45	—
7.49	—	1.05	—
10.03	0.305	0.84	0.391
11.3	0.284	0.76	0.406
12.57	0.265	0.70	0.414
13.84	0.247	0.64	0.426
15.11	0.230	0.60	0.426
16.38	0.214	0.56	0.428
17.65	0.199	0.52	0.433
18.92	0.186	0.47	0.454
20.19	0.174	0.45	0.446
21.46	0.164	0.425	0.449
22.73	0.154	0.40	0.453
24.0	0.146	0.38	0.456
25.27	0.139	0.355	0.471
26.54	—	0.33	—
27.81	—	0.28	—
29.08	—	—	—

wide – 0.436 ± 0.017

narrow – 0.437 ± 0.012

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2

DATE: DEC. 3/87

Additions made to sample:

4.57 g SiO_2 to 100 g as-received slag

Atm.: High purity Ar (gettered)

Total wt. of sample: 104.57 g

Total wt. w/crucible: init.- 151.50 g
fin1.- 151.44 g

RUN#: 2

TEMPERATURE: 1300 °C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	121	0.0	3.6
3	82	4.95	1.32
1	62	7.49	0.98
1	42	10.03	0.79
1	32	11.3	0.72
1	22	12.57	0.66
1	12	13.84	0.60
1	02	15.11	0.56
1	992	16.38	0.52
1	982	17.65	0.49
1	972	18.92	0.46
1	962	20.19	0.43
1	952	21.46	0.41
1	942	22.73	0.385
1	932	24.0	0.36
1	922	25.27	0.34
1	912	26.54	0.31
1	902	27.81	0.26
1	892	29.08	0.04 – BOTTOM
		Depth - 29.0 mm	

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 0.85 Fe/SiO$_2$

TEMPERATURE: 1300°C ± 5°

DATE: DEC. 3/87

Atm.: AP. Ar

$r_{ext.}$ = 0.04Ω

RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY (ohm^{-1}.cm^{-1})
0.0	—	3.6	—
4.95	—	1.32	—
7.49	—	0.98	—
10.03	0.305	0.79	0.407
11.3	0.284	0.72	0.418
12.57	0.265	0.66	0.427
13.84	0.247	0.60	0.441
15.11	0.230	0.56	0.442
16.38	0.214	0.52	0.446
17.65	0.199	0.49	0.442
18.92	0.186	0.46	0.443
20.19	0.174	0.43	0.446
21.46	0.164	0.41	0.443
22.73	0.154	0.385	0.446
24.0	0.146	0.36	0.456
25.27	0.139	0.34	0.463
26.54	—	0.31	—
27.81	—	0.26	—
29.08	—	—	—

wide – 0.441 ± 0.010

narrow – 0.444 ± 0.002

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2

DATE: DEC. 3/87

Additions made to sample:

4.57 g SiO_2 to 100 g as-received slag.

Atm.: High purity Ar (getered)

Total wt. of sample: 104.57 g

Total wt. w/crucible: init.- 151.50 g
fin1.- 151.44 g

RUN#: 3

TEMPERATURE: 1300 °C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	121	0.0	3.7
3	82	4.95	1.3
3	62	7.49	0.95
1	42	10.03	0.80
1	32	11.3	0.72
1	22	12.57	0.66
1	12	13.84	0.60
1	02	15.11	0.56
1	992	16.38	0.52
1	982	17.65	0.49
1	972	18.92	0.46
1	962	20.19	0.435
1	952	21.46	0.405
1	942	22.73	0.385
1	932	24.0	0.3~~4~~5
1	922	25.27	0.34
1	912	26.54	0~~35~~.31
1	902	27.81	0.26
1	892	29.08	0.04 - BOTTOM
		Depth = 29.0 mm.	

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: $0.85\ Fe/SiO_2$

TEMPERATURE: 1300°C ± 5°

DATE: DEC. 3/87

Atm.: HP. Ar

$r_{ext.} = 0.04\Omega$

RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	3.7	—
4.95	—	1.3	—
7.49	—	0.95	—
10.03	0.305	0.80	0.401
11.3	0.284	0.72	0.418
12.57	0.265	0.66	0.427
13.84	0.247	0.60	0.441
15.11	0.230	0.56	0.442
16.38	0.214	0.52	0.446
17.65	0.199	0.49	0.442
18.92	0.186	0.46	0.443
20.19	0.174	0.435	0.441
21.46	0.164	0.405	0.449
22.73	0.154	0.385	0.446
24.0	0.146	0.35	0.471
25.27	0.139	0.34	0.463
26.54	—	0.31	—
27.81	—	0.26	—
29.08	—	—	—

wide - 0.442 ± 0.013

narrow - 0.443 ± 0.002

X

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 3/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: High purity Ar (gettered).

SLAG SAMPLE: 0.85 Fe/SiO_2

TEMPERATURE: 1300 °C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG. (#2+3 only)
	RUN# 1	RUN# 2	RUN# 3	
0.0	3.54	3.6	3.7	3.65
4.95	1.45	1.32	1.3	1.31
7.49	1.05	0.98	0.95	0.965
10.03	0.84	0.79	0.80	0.795
11.3	0.76	0.72	0.72	0.72
12.57	0.70	0.66	0.66	0.66
13.84	0.64	0.60	0.60	0.60
15.11	0.60	0.56	0.56	0.56
16.38	0.56	0.52	0.52	0.52
17.65	0.52	0.49	0.49	0.49
18.92	0.47	0.46	0.46	0.46
20.19	0.45	0.43	0.435	0.4325
21.46	0.425	0.41	0.405	0.4075
22.73	0.40	0.385	0.385	0.385
24.0	0.38	0.36	0.35	0.355
25.27	0.355	0.34	0.34	0.34
26.54	0.33	0.31	0.31	0.31
27.81	0.28	0.26	0.26	0.26
29.08	0.06 ——	0.04 ——	0.04 ——	0.04 Rext.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 3/87

SLAG SAMPLE: 0.85 Fe/SiO_2

Atm.: High purity Ar (gettered).

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.04 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (#2+3)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	3.65	—
4.95	—	1.31	—
7.49	—	0.965	—
10.03	0.305	0.795	0.404
11.3	0.284	0.72	0.418
12.57	0.265	0.66	0.427
13.84	0.247	0.60	0.441
15.11	0.230	0.56	0.442
16.38	0.214	0.52	0.446
17.65	0.199	0.49	0.442
18.92	0.186	0.46	0.443
20.19	0.174	0.4325	0.443
21.46	0.164	0.4075	0.446
22.73	0.154	0.385	0.446
24.0	0.146	0.355	0.463
25.27	0.139	0.34	0.463
26.54	—	0.31	—
27.81	—	0.26	—
29.08	—	0.04	—

wide – 0.442 ± 0.011

narrow – 0.443 ± 0.0016

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 3/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar.

SLAG SAMPLE: 0.85 Fe/SiO_2

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	3.5	3.6	3.7	3.60
4.95	1.45	1.32	1.3	1.357
7.49	1.05	0.98	0.95	0.993
10.03	0.84	0.79	0.80	0.810
11.3	0.76	0.72	0.72	0.733
12.57	0.70	0.66	0.66	0.673
13.84	0.64	0.60	0.60	0.613
15.11	0.60	0.56	0.56	0.573
16.38	0.56	0.52	0.52	0.533
17.65	0.52	0.49	0.49	0.500
18.92	0.47	0.46	0.46	0.463
20.19	0.45	0.43	0.435	0.438
21.46	0.425	0.41	0.405	0.413
22.73	0.40	0.385	0.385	0.390
24.0	0.38	0.36	0.35	0.363
25.27	0.355	0.34	0.34	0.345
26.54	0.33	0.31	0.31	0.317
27.81	0.28	0.26	0.26	0.267
29.08	0.06	0.04	0.04	0.047

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 3/87

SLAG SAMPLE: 0.85 Fe/SiO_2

Atm.: H.P. Ar.

TEMPERATURE: 1300 °C ± 5°

$r_{ext.}$ = 0.047 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	3.60	—
4.95	—	1.357	—
7.49	—	0.993	—
10.03	0.305	0.810	0.400
11.3	0.284	0.733	0.414
12.57	0.265	0.673	0.423
13.84	0.247	0.613	0.436
15.11	0.230	0.573	0.437
16.38	0.214	0.533	0.440
17.65	0.199	0.500	0.439
18.92	0.186	0.463	0.447
20.19	0.174	0.438	0.445
21.46	0.164	0.413	0.448
22.73	0.154	0.390	0.449
24.0	0.146	0.363	0.462
25.27	0.139	0.345	0.466
26.54	—	0.317	—
27.81	—	0.267	—
29.08	—	—	—

wide – 0.440 ± 0.013

narrow – 0.442 ± 0.004

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt% Fe_2O_3 DATE: DEC. 6/87

Additions made to sample: Atm.: H.P. Ar (gettered).

100g as-received + 4.57g SiO_2 + 5.23g Fe_2O_3

Total wt. of sample: 109.80g Total wt. w/crucible: init.- 159.51g

finl.- 159.34g

RUN#: 1 TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10(3)	116	0.0	2.5 (2.85)
3	77	4.95	0.95
1	57	7.49	0.78
1	37	10.03	0.63
1	27	11.3	0.58
1	17	12.57	0.525
1	07	13.84	0.485
1	997	15.11	0.445
1	987	16.38	0.42
1	977	17.65	0.385
1	967	18.92	0.36
1	957	20.19	0.34
1	947	21.46	0.32
1	937	22.73	0.30
1	927	24.0	0.28
1	917	25.27	0.26
1	907	26.54	0.245
1	897	27.81	0.22
1	887	29.08	0.16
1 —	— 877 —	— 30.35 —	— 0.03 - BOTTOM
		Depth = 30.35 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% Fe_2O_3

DATE: DEC. 6/87

Atm.: U.P. Ar.

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.03 Ω

RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.85	———
4.95	———	0.95	———
7.49	———	0.78	———
10.03	0.305	0.63	0.508
11.3	0.284	0.58	0.516
12.57	0.265	0.525	0.535
13.84	0.247	0.485	0.543
15.11	0.230	0.445	0.554
16.38	0.214	0.42	0.549
17.65	0.199	0.385	0.561
18.92	0.186	0.36	0.564
20.19	0.174	0.34	0.561
21.46	0.164	0.32	0.566
22.73	0.154	0.30	0.570
24.0	0.146	0.28	0.584
25.27	0.139	0.26	0.604
26.54	———	0.245	———
27.81	———	0.22	———
29.08	———	0.16	———

wide – 0.555 ± 0.019

narrow – 0.558 ± 0.006

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt% Fe_2O_3

DATE: DEC. 6/87

Additions made to sample:

100 g as-received + 4.57 g SiO_2 + 5.23 g Fe_2O_3

Atm.: H.P. Ar (gettered).

Total wt. of sample: 109.80 g

Total wt. w/crucible: init.- 159.51 g

finl.- 159.34 g

RUN#: 2

TEMPERATURE: 1250 °C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	116	0.0	2.85
3	77	4.95	0.95
1	57	7.49	0.80
1	37	10.03	0.64
1	27	11.3	0.58
1	17	12.57	0.53
1	07	13.84	0.49
1	997	15.11	0.445
1	987	16.38	0.42
1	977	17.65	0.39
1	967	18.92	0.365
1	957	20.19	0.34
1	947	21.46	0.32
1	937	22.73	0.30
1	927	24.0	0.285
1	917	25.27	0.265
1	907	26.54	0.25
1	897	27.81	0.22
1	887	29.08	0.18
1	877	30.35	0.03- BOTTOM.
		Depth = 30.35 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 6/87

SLAG SAMPLE: 0.85 Fe/SiO$_2$ with 5wt.% Fe$_2$O$_3$

Atm.: H.P. Ar

TEMPERATURE: 1250°C ± 5°

$r_{ext.} = 0.03\ \Omega$

RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY (ohm^{-1}.cm^{-1})
0.0	—	2.85	—
4.95	—	0.95	—
7.49	—	0.80	—
10.03	0.305	0.64	0.500
11.3	0.284	0.58	0.516
12.57	0.265	0.53	0.530
13.84	0.247	0.49	0.537
15.11	0.230	0.445	0.554
16.38	0.214	0.42	0.549
17.65	0.199	0.39	0.553
18.92	0.186	0.365	0.555
20.19	0.174	0.34	0.561
21.46	0.164	0.32	0.566
22.73	0.154	0.30	0.570
24.0	0.146	0.285	0.573
25.27	0.139	0.265	0.591
26.54	—	0.25	—
27.81	—	0.22	—
29.08	—	0.18	—

wide – 0.551 ± 0.018

narrow – 0.554 ± 0.004

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% Fe_2O_3

DATE: DEC. 6/87

Additions made to sample:

100 g as-received + 4.57g SiO_2 + 5.23g Fe_2O_3

Atm.: H.P. Ar (gettered)

Total wt. of sample: 109.80g

Total wt. w/crucible: init.- 159.51g.
fin1.- 159.34g

RUN#: 3

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	114	0.0	2.7
3	75	4.95	0.96
1	55	7.49	0.80
1	35	10.03	0.65
1	25	11.3	0.59
1	15	12.57	0.54
1	05	13.84	0.50
1	995	15.11	0.465
1	985	16.38	0.435
1	975	17.65	0.40
1	965	18.92	0.375
1	955	20.19	0.35
1	945	21.46	0.33
1	935	22.73	0.31
1	925	24.0	0.29
1	915	25.27	0.27
1	905	26.54	0.25
1	895	27.81	0.225
1	885	29.08	0.18
1	875	30.35	0.03 – BOTTOM
		Depth = 30.35 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 6/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt% Fe_2O_3

Atm.: H.P. Ar.

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.03 Ω

RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.7	———
4.95	———	0.96	———
7.49	———	0.80	———
10.03	0.305	0.65	0.492
11.3	0.284	0.59	0.507
12.57	0.265	0.54	0.520
13.84	0.247	0.50	0.526
15.11	0.230	0.465	0.529
16.38	0.214	0.435	0.528
17.65	0.199	0.40	0.538
18.92	0.186	0.375	0.539
20.19	0.174	0.35	0.544
21.46	0.164	0.33	0.547
22.73	0.154	0.31	0.550
24.0	0.146	0.29	0.562
25.27	0.139	0.27	0.579
26.54	———	0.25	———
27.81	———	0.225	———
29.08	———	0.18	———

wide – 0.535 ± 0.015

narrow – 0.536 ± 0.007

SLAG CONDUCTIVITY DETERMINATION

SUMMARY OF RESISTANCE MEASUREMENTS:

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt.% Fe_2O_3

TEMPERATURE: 1250°C ± 5°

DATE: DEC. 6/87

Atm.: HP. Ar.

DEPTH (mm)	RESISTANCE (ohms)			AVG. (#1+2)
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.85	2.85	2.7	2.85
4.95	0.95	0.95	0.96	0.950
7.49	0.78	0.80	0.80	0.790
10.03	0.63	0.64	0.65	0.635
11.3	0.58	0.58	0.59	0.580
12.57	0.525	0.53	0.54	0.528
13.84	0.485	0.49	0.50	0.488
15.11	0.445	0.445	0.465	0.445
16.38	0.42	0.42	0.435	0.420
17.65	0.385	0.39	0.40	0.388
18.92	0.36	0.365	0.375	0.363
20.19	0.34	0.34	0.35	0.340
21.46	0.32	0.32	0.33	0.320
22.73	0.30	0.30	0.31	0.300
24.0	0.28	0.285	0.29	0.285
25.27	0.26	0.265	0.27	0.263
26.54	0.245	0.25	0.25	0.248
27.81	0.22	0.22	0.225	0.220
29.08	0.16	0.18	0.18	0.170
30.35	0.03 ——	0.03 ——	0.03 ——	0.03 Rext.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 6/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% Fe_2O_3

Atm.: HP. Ar

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.03Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (*1+2)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.85	———
4.95	———	0.950	———
7.49	———	0.790	———
10.03	0.305	0.635	0.504
11.3	0.284	0.580	0.516
12.57	0.265	0.528	0.532
13.84	0.247	0.488	0.539
15.11	0.230	0.445	0.554
16.38	0.214	0.420	0.549
17.65	0.199	0.388	0.556
18.92	0.186	0.363	0.559
20.19	0.174	0.340	0.561
21.46	0.164	0.320	0.566
22.73	0.154	0.300	0.570
24.0	0.146	0.285	0.573
25.27	0.139	0.263	0.597
26.54	———	0.248	———
27.81	———	0.220	———
29.08	———	0.170	———

wide - 0.552 ± 0.017

narrow - 0.556 ± 0.005

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 6/87
Atm.: A.P. Ar.

SUMMARY OF RESISTANCE MEASUREMENTS:

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt.% Fe_2O_3

TEMPERATURE: 1250°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.85	2.85	2.7	2.80
4.95	0.95	0.95	0.96	0.953
7.49	0.78	0.80	0.80	0.793
10.03	0.63	0.64	0.65	0.640
11.3	0.58	0.58	0.59	0.583
12.57	0.525	0.53	0.54	0.532
13.84	0.485	0.49	0.50	0.492
15.11	0.445	0.445	0.465	0.452
16.38	0.42	0.42	0.435	0.425
17.65	0.385	0.39	0.40	0.392
18.92	0.36	0.365	0.375	0.367
20.19	0.34	0.34	0.35	0.343
21.46	0.32	0.32	0.33	0.323
22.73	0.30	0.30	0.31	0.303
24.0	0.28	0.285	0.29	0.285
25.27	0.26	0.265	0.27	0.265
26.54	0.245	0.25	0.25	0.248
27.81	0.22	0.22	0.225	0.222
29.08	0.16	0.18	0.18	0.173
30.35	0.03 —	0.03 —	0.03 —	0.03 R_{ext}

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 6/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% Fe_2O_3

Atm.: H.P. Ar

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.03 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.80	———
4.95	———	0.953	———
7.49	———	0.793	———
10.03	0.305	0.640	0.500
11.3	0.284	0.583	0.514
12.57	0.265	0.532	0.528
13.84	0.247	0.492	0.535
15.11	0.230	0.452	0.545
16.38	0.214	0.425	0.542
17.65	0.199	0.392	0.550
18.92	0.186	0.367	0.552
20.19	0.174	0.343	0.556
21.46	0.164	0.323	0.560
22.73	0.154	0.303	0.564
24.0	0.146	0.285	0.573
25.27	0.139	0.265	0.591
26.54	———	0.248	———
27.81	———	0.222	———
29.08	———	0.173	———

wide – 0.547 ± 0.017

narrow – 0.549 ± 0.006.

SLAG CONDUCTIVITY DETERMINATION X

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% Fe_2O_3 DATE: DEC. 6/87

Additions made to sample: Atm.: H.P. Ar (gettered)

100g as-received + 4.57 SiO_2 + 5.23g Fe_2O_3

Total wt. of sample: 109.80g Total wt. w/crucible: init.- 159.51g

finl.- 159.34g

RUN#: 1 TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	112	0.0	2.25
1	73	4.95	0.90
1	53	7.49	0.70
1	33	10.03	0.58
1	23	11.3	0.55
1	13	12.57	0.495
1	03	13.84	0.46
1	993	15.11	0.425
1	983	16.38	0.40
1	973	17.65	0.375
1	963	18.92	0.355
1	953	20.19	~~[illegible]~~ 0.335
1	943	21.46	0.315
1	933	22.73	0.30
1	923	24.0	0.28
1	913	25.27	0.265
1	903	26.54	0.245
1	893	27.81	0.22
1	883	29.08	0.13
1 —	873 —	30.35 —	0.10 — BOTTOM.
		Depth = 30.35 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 6/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% Fe_2O_3

Atm.: H.P. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.10 Ω RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	——	2.25	——
4.95	——	0.90	——
7.49	——	0.70	——
10.03	0.305	0.58	0.635
11.3	0.284	0.55	0.631
12.57	0.265	0.495	0.671
13.84	0.247	0.46	0.686
15.11	0.230	0.425	0.708
16.38	0.214	0.40	0.713
17.65	0.199	0.375	0.724
18.92	0.186	0.355	0.729
20.19	0.174	0.335	0.740
21.46	0.164	0.315	0.763
22.73	0.154	0.30	0.770
24.0	0.146	0.28	0.811
25.27	0.139	0.265	0.842
26.54	——	0.245	——
27.81	——	0.22	——
29.08	——	0.13	——

wide – 0.722 ± 0.050

narrow – 0.723 ± 0.013

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt.% Fe_2O_3

DATE: DEC. 6/87

Additions made to sample:

100 g as-received + 4.57 SiO_2 + 5.23 g Fe_2O_3

Atm.: A.P. Ar (gettered).

Total wt. of sample: 109.80 g

Total wt. w/crucible: init.- 159.51 g

finl.- 159.34 g

RUN#: 2

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	114	0.0	2.30
1	75	4.95	0.925
1	55	7.49	0.72
1	35	10.03	0.59
1	25	11.3	0.54
1	15	12.57	0.495
1	05	13.84	0.455
1	995	15.11	0.42
1	985	16.38	0.39
1	975	17.65	0.365
1	965	18.92	0.34
1	955	20.19	0.32
1	945	21.46	0.30
1	935	22.73	0.285
1	925	24.0	0.270
1	915	25.27	0.25
1	905	26.54	0.235
1	895	27.81	0.21
1	885	29.08	0.17
1		BOTTOM.	0.08
		Depth = 30.35 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 6/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% Fe_2O_3

Atm.: H.P. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.08 Ω **RUN#:** 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.30	———
4.95	———	0.925	———
7.49	———	0.72	———
10.03	0.305	0.59	0.598
11.3	0.284	0.54	0.617
12.57	0.265	0.495	0.639
13.84	0.247	0.455	0.659
15.11	0.230	0.42	0.676
16.38	0.214	0.39	0.690
17.65	0.199	0.365	0.698
18.92	0.186	0.34	0.715
20.19	0.174	0.32	0.725
21.46	0.164	0.30	0.745
22.73	0.154	0.285	0.751
24.0	0.146	0.270	0.768
25.27	0.139	0.25	0.818
26.54	———	0.235	———
27.81	———	0.21	———
29.08	———	0.17	———

wide - 0.698 ± 0.048

narrow - 0.701 ± 0.020

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe / SiO_2 with 5wt.% Fe_2O_3

DATE: DEC. 6/87

Additions made to sample:

100 g as-received + 4.57 g SiO_2 + 5.23 g Fe_2O_3

Atm.: H.P. Ar (gettered)

Total wt. of sample: 109.80 g

Total wt. w/crucible: init.- 159.51 g

finl.- 159.34 g

RUN#: 3

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	114	0.0	2.40
1	75	4.95	0.96
1	55	7.49	0.745
1	35	10.03	0.615
1	25	11.3	0.565
1	15	12.57	0.525
1	05	13.84	0.485
1	995	15.11	0.455
1	985	16.38	0.43
1	975	17.65	0.40
1	965	18.92	0.38
1	955	20.19	0.36
1	945	21.46	0.34
1	935	22.73	0.32
1	925	24.0	0.305
1	915	25.27	0.29
1	905	26.54	0.27
1	895	27.81	0.25
1	885	29.08	0.21
1	— BOTTOM	—	0.10
		Depth = 30.35 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC.6/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt.% Fe_2O_3

Atm.: H.P. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.10 Ω **RUN#:** 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.40	———
4.95	———	0.96	———
7.49	———	0.745	———
10.03	0.305	0.615	0.592
11.3	0.284	0.565	0.611
12.57	0.265	0.525	0.624
13.84	0.247	0.485	0.642
15.11	0.230	0.455	0.648
16.38	0.214	0.43	0.648
17.65	0.199	0.40	0.663
18.92	0.186	0.38	0.664
20.19	0.174	0.36	0.669
21.46	0.164	0.34	0.683
22.73	0.154	0.32	0.700
24.0	0.146	0.305	0.712
25.27	0.139	0.29	0.732
26.54	———	0.27	———
27.81	———	0.25	———
29.08	———	0.21	———

wide – 0.660 ± 0.030

narrow – 0.658 ± 0.010

SLAG CONDUCTIVITY DETERMINATION

SUMMARY OF RESISTANCE MEASUREMENTS:

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt.% Fe_2O_3

TEMPERATURE: 1300°C ± 5°

DATE: DEC. 6/87

Atm.: H.P. Ar (gettered)

DEPTH (mm)	RESISTANCE (ohms)			AVG. (#1+2 only)
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.25	2.30	2.40	2.275
4.95	0.90	0.925	0.96	0.9125
7.49	0.70	0.72	0.745	0.71
10.03	0.58	0.59	0.615	0.585
11.3	0.55	0.54	0.565	0.545
12.57	0.495	0.495	0.525	0.495
13.84	0.46	0.455	0.485	0.455
15.11	0.425	0.42	0.455	0.422
16.38	0.40	0.39	0.43	0.395
17.65	0.375	0.365	0.40	0.37
18.92	0.355	0.34	0.38	0.3475
20.19	0.335	0.32	0.36	0.330
21.46	0.315	0.30	0.34	0.310
22.73	0.30	0.285	0.32	0.2925
24.0	0.28	0.270	0.305	0.275
25.27	0.265	0.25	0.29	0.2575
26.54	0.245	0.235	0.27	0.240
27.81	0.22	0.210	0.25	0.215
29.08	0.13	0.170	0.21	0.15
30.35	0.10	0.08	0.10	0.09 Rext.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION: (

DATE: DEC. 6/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% Fe_2O_3

Atm.: U.P. Ar (Gettered).

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.09 Ω

DEPTH (mm)	CELL CONSTANT (cm⁻¹)	RESISTANCE (ohm) (#1+2)	CONDUCTIVITY (ohm⁻¹.cm⁻¹)
0.0	———	2.275	———
4.95	———	0.913	———
7.49	———	0.710	———
10.03	0.305	0.585	0.616
11.3	0.284	0.545	0.624
12.57	0.265	0.495	0.654
13.84	0.247	0.455	0.677
15.11	0.230	0.422	0.693
16.38	0.214	0.395	0.702
17.65	0.199	0.370	0.711
18.92	0.186	0.348	0.721
20.19	0.174	0.330	0.725
21.46	0.164	0.310	0.745
22.73	0.154	0.293	0.759
24.0	0.146	0.275	0.789
25.27	0.139	0.258	0.827
26.54	———	0.240	———
27.81	———	0.215	———
29.08	———	0.15	———
30.35	———	0.09	———

wide - 0.708 ± 0.048

narrow - 0.710 ± 0.013

SLAG CONDUCTIVITY DETERMINATION

SUMMARY OF RESISTANCE MEASUREMENTS:

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% Fe_2O_3

TEMPERATURE: 1300 °C ± 5°

DATE: DEC.6/87

Atm.: H.P. Ar

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.25	2.30	2.40	2.32
4.95	0.90	0.925	0.96	0.928
7.49	0.70	0.72	0.745	0.722
10.03	0.58	0.59	0.615	0.595
11.3	0.55	0.54	0.565	0.552
12.57	0.495	0.495	0.525	0.505
13.84	0.46	0.455	0.485	0.467
15.11	0.425	0.42	0.455	0.433
16.38	0.40	0.39	0.43	0.407
17.65	0.375	0.365	0.40	0.380
18.92	0.355	0.34	0.38	0.358
20.19	0.335	0.32	0.36	0.338
21.46	0.315	0.30	0.34	0.318
22.73	0.30	0.285	0.32	0.302
24.0	0.28	0.27	0.305	0.285
25.27	0.265	0.25	0.29	0.268
26.54	0.245	0.235	0.27	0.250
27.81	0.22	0.210	0.25	0.227
29.08	0.13	0.17	0.21	0.170
30.35	0.10	0.08	0.10	0.093 Rest.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 6 /87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt% Fe_2O_3

Atm.: H.P. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.093 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.32	———
4.95	———	0.928	———
7.49	———	0.722	———
10.03	0.305	0.595	0.608
11.3	0.284	0.552	0.619
12.57	0.265	0.505	0.643
13.84	0.247	0.467	0.660
15.11	0.230	0.433	0.676
16.38	0.214	0.407	0.682
17.65	0.199	0.380	0.693
18.92	0.186	0.358	0.702
20.19	0.174	0.338	0.710
21.46	0.164	0.318	0.729
22.73	0.154	0.302	0.737
24.0	0.146	0.285	0.760
25.27	0.139	0.268	0.794
26.54	———	0.250	———
27.81	———	0.227	———
29.08	———	0.170	———

wide- 0.692 ± 0.042

narrow- 0.693 ± 0.013

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% CaO

DATE: DEC. 8/87

Additions made to sample:

100g as-received + 4.57g SiO_2 + 5.23 g CaO

Atm.: H.P. Ar (gettered).

Total wt. of sample: 109.80g

Total wt. w/crucible: init.- 159.91 g
finl.- 159.58g

RUN#: 1

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	136	0.0	4.35
3	97	4.95	1.5
3	77	7.49	1.1
1	57	10.03	0.93
1	47	11.3	0.82
1	37	12.57	0.76
1	27	13.84	0.71
1	17	15.11	0.655
1	07	16.38	0.605
1	997	17.65	0.565
1	987	18.92	0.53
1	977	20.19	0.50
1	967	21.46	0.47
1	957	22.73	0.44
1	947	24.0	0.415
1	937	25.27	0.39
1	927	26.54	0.365
1	917	27.81	0.34
1	907	29.08	0.30
.3	~897	30.35	0.07 – BOTTOM.
		Depth = 30.35 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 0.85 Fe/SiO$_2$ with 5wt.% CaO

DATE: DEC. 8 /87

Atm.: H.P. Ar

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.07 Ω RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY (ohm^{-1}.cm^{-1})
0.0	———	4.35	———
4.95	———	1.5	———
7.49	———	1.1	———
10.03	0.305	0.93	0.355
11.3	0.284	0.82	0.379
12.57	0.265	0.76	0.384
13.84	0.247	0.71	0.386
15.11	0.230	0.655	0.393
16.38	0.214	0.605	0.400
17.65	0.199	0.565	0.402
18.92	0.186	0.53	0.404
20.19	0.174	0.50	0.405
21.46	0.164	0.47	0.410
22.73	0.154	0.44	0.416
24.0	0.146	0.415	0.423
25.27	0.139	0.39	0.434
26.54	———	0.365	———
27.81	———	0.34	———
29.08	———	0.30	———

wide - 0.400 ± 0.014

narrow - 0.401 ± 0.005

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt.% CaO

DATE: DEC. 8/87

Additions made to sample:

Atm.: H.P. Ar (gettered)

100g as-received + 4.57g SiO_2 + 5.23g CaO

Total wt. of sample: 109.80g

Total wt. w/crucible: init.- 159.91g
finl.- 159.58g

RUN#: 2

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	134	0.0	3.65
3	95	4.95	1.45
3	75	7.49	1.1
1	55	10.03	0.905
1	45	11.3	0.825
1	35	12.57	0.755
1	25	13.84	0.69
1	15	15.11	0.645
1	05	16.38	0.60
1	995	17.65	0.56
1	985	18.92	0.525
1	975	20.19	0.49
1	965	21.46	0.46
1	955	22.73	0.435
1	945	24.0	0.41
1	935	25.27	0.395
1	925	26.54	0.365
1	915	27.81	0.34
1	905	29.08	0.29
1	895	30.35	0.07 BOTTOM
		Depth 30.35mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC 8/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% CaO

Atm.: H.P. Ar

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.07 Ω RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	3.65	—
4.95	—	1.45	—
7.49	—	1.1	—
10.03	0.305	0.905	0.365
11.3	0.284	0.825	0.376
12.57	0.265	0.755	0.387
13.84	0.247	0.69	0.398
15.11	0.230	0.645	0.400
16.38	0.214	0.60	0.404
17.65	0.199	0.56	0.406
18.92	0.186	0.525	0.409
20.19	0.174	0.49	0.414
21.46	0.164	0.46	0.421
22.73	0.154	0.435	0.422
24.0	0.146	0.41	0.429
25.27	0.139	0.395	0.428
26.54	—	0.365	—
27.81	—	0.34	—
29.08	—	0.29	—

wide – 0.406 ± 0.016

narrow – 0.407 ± 0.005

SLAG CONDUCTIVITY DETERMINATION

X

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% CaO

DATE: DEC. 8/87

Additions made to sample:

100g as-received + 4.57g SiO_2 + 5.23g CaO

Atm.: H.P. Ar (gettered)

Total wt. of sample: 109.80 g

Total wt. w/crucible: init.- 159.91 g
finl.- 159.58g

RUN#: 3

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	134	0.0	3.8
3	95	4.95	1.5
3	75	7.49	1.125
1	55	10.03	0.92
1	45	11.3	0.84
1	35	12.57	0.77
1	25	13.84	0.71
1	15	15.11	0.66
1	05	16.38	0.61
1	995	17.65	0.57
1	985	18.92	0.54
1	975	20.19	0.50
1	965	21.46	0.475
1	955	22.73	0.45
1	945	24.0	0.42
1	935	25.27	0.40
1	925	26.54	0.37
1	915	27.81	0.345
1	905	29.08	0.30
1	895	30.35	0.07 BOTTOM
		Depth. 30.35 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 8/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% CaO

Atm.: H.P. Ar.

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.07Ω RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	3.8	—
4.95	—	1.5	—
7.49	—	1.125	—
10.03	0.305	0.92	0.359
11.3	0.284	0.84	0.369
12.57	0.265	0.77	0.379
13.84	0.247	0.71	0.386
15.11	0.230	0.66	0.390
16.38	0.214	0.61	0.396
17.65	0.199	0.57	0.398
18.92	0.186	0.54	0.396
20.19	0.174	0.50	0.405
21.46	0.164	0.475	0.405
22.73	0.154	0.45	0.405
24.0	0.146	0.42	0.417
25.27	0.139	0.40	0.421
26.54	—	0.37	—
27.81	—	0.345	—
29.08	—	0.30	—

wide – 0.395 ± 0.014

narrow – 0.397 ± 0.005

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 8/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar (gettered).

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% CaO

TEMPERATURE: 1250°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	4.35	3.65	3.8	3.93
4.95	1.5	1.45	1.5	1.483
7.49	1.1	1.1	1.125	1.108
10.03	0.93	0.905	0.92	0.918
11.3	0.82	0.825	0.84	0.828
12.57	0.76	0.755	0.77	0.762
13.84	0.71	0.69	0.71	0.703
15.11	0.655	0.645	0.66	0.653
16.38	0.605	0.60	0.61	0.605
17.65	0.565	0.56	0.57	0.565
18.92	0.53	0.525	0.54	0.532
20.19	0.50	0.49	0.50	0.497
21.46	0.47	0.46	0.475	0.468
22.73	0.44	0.435	0.45	0.442
24.0	0.415	0.41	0.42	0.415
25.27	0.39	0.395	0.40	0.395
26.54	0.365	0.365	0.37	0.367
27.81	0.34	0.34	0.345	0.342
29.08	0.30	0.29	0.30	0.297
30.35	0.07	0.07	0.07	0.07 Ref.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 8/87

SLAG SAMPLE: 0.85 Fe/SiO$_2$ with 5 wt.% CaO

Atm.: H.P. Ar (gettered)

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.07 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY (ohm^{-1}.cm^{-1})
0.0	——	3.93	——
4.95	——	1.483	——
7.49	——	1.108	——
10.03	0.305	0.918	0.360
11.3	0.284	0.828	0.375
12.57	0.265	0.762	0.383
13.84	0.247	0.703	0.390
15.11	0.230	0.653	0.395
16.38	0.214	0.605	0.400
17.65	0.199	0.565	0.402
18.92	0.186	0.532	0.403
20.19	0.174	0.497	0.408
21.46	0.164	0.468	0.412
22.73	0.154	0.442	0.414
24.0	0.146	0.415	0.423
25.27	0.139	0.395	0.428
26.54	——	0.367	——
27.81	——	0.342	——
29.08	——	0.297	——

wide – 0.400 ± 0.014

narrow – 0.402 ± 0.005

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt.% CaO

DATE: DEC. 8/87

Additions made to sample:

100 g as-received + 4.57 g SiO_2 + 5.23 g CaO

Atm.: H.P. Ar (gettered).

Total wt. of sample: 109.80 g

Total wt. w/crucible: init.- 159.91 g
finl.- 159.58 g

RUN#: 1

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	133	0.0	3.0
3	94	4.95	1.175
1	74	7.49	0.93
1	54	10.03	0.76
1	44	11.3	0.70
1	34	12.57	0.64
1	24	13.84	0.59
1	14	15.11	0.55
1	04	16.38	0.51
1	994	17.65	0.48
1	984	18.92	0.45
1	974	20.19	0.42
1	964	21.46	0.40
1	954	22.73	0.38
1	944	24.0	0.355
1	934	25.27	0.335
1	924	26.54	0.315
1	914	27.81	0.285
1	904	29.08	0.25
1	~894 —	— 30.35 —	— 0.07 BOTTOM.
		Depth 30.35 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt% CaO

DATE: DEC. 8/87

Atm.: H.P. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.07 Ω **RUN#:** 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	3.0	—
4.95	—	1.175	—
7.49	—	0.93	—
10.03	0.305	0.76	0.442
11.3	0.284	0.70	0.451
12.57	0.265	0.64	0.465
13.84	0.247	0.59	0.475
15.11	0.230	0.55	0.479
16.38	0.214	0.51	0.486
17.65	0.199	0.48	0.485
18.92	0.186	0.45	0.489
20.19	0.174	0.42	0.497
21.46	0.164	0.40	0.497
22.73	0.154	0.38	0.497
24.0	0.146	0.355	0.512
25.27	0.139	0.335	0.525
26.54	—	0.315	—
27.81	—	0.285	—
29.08	—	0.25	—

wide - 0.485 ± 0.017

narrow - 0.498 ± 0.008

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% CaO

DATE: DEC. 8/87

Additions made to sample:

100g as-received + 4.57g SiO_2 + 5.23g CaO

Atm.: H.P. Ar (gettered)

Total wt. of sample: 109.80g

Total wt. w/crucible: **init.**- 159.91g
finl.- 159.58g

RUN#: 2

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	133	0.0	3.0
3	94	4.95	1.2
1	74	7.49	0.96
1	54	10.03	0.78
1	44	11.3	0.71
1	34	12.57	0.65
1	24	13.84	0.605
1	14	15.11	0.56
1	04	16.38	0.525
1	994	17.65	0.49
1	984	18.92	0.46
1	974	20.19	0.435
1	964	21.46	0.41
1	954	22.73	0.39
1	944	24.0	0.37
1	934	25.27	0.35
1	924	26.54	0.325
1	914	27.81	0.30
1	904	29.08	0.265
1 —	894 —	30.35 —	0.07 BOTTOM.
		Depth 30.35mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% CaO

DATE: DEC. 8/87

Atm.: H.P. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.07 Ω RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	3.0	———
4.95	———	1.2	———
7.49	———	0.96	———
10.03	0.305	0.78	0.430
11.3	0.284	0.71	0.444
12.57	0.265	0.65	0.457
13.84	0.247	0.605	0.462
15.11	0.230	0.56	0.469
16.38	0.214	0.525	0.470
17.65	0.199	0.49	0.474
18.92	0.186	0.46	0.477
20.19	0.174	0.435	0.477
21.46	0.164	0.41	0.482
22.73	0.154	0.39	0.481
24.0	0.146	0.37	0.487
25.27	0.139	0.35	0.496
26.54	———	0.325	———
27.81	———	0.30	———
29.08	———	0.265	———

wide - 0.471 ± 0.013

narrow - 0.481 ± 0.004

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt.% CaO

DATE: DEC. 8/87

Additions made to sample:

100g as-received + 4.57g SiO_2 + 5.23g CaO

Atm.: H.P. Ar (gettered).

Total wt. of sample: 109.80g

Total wt. w/crucible: init.- 159.91g

finl.- 159.58g

RUN#: 3

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	133	0.0	2.5
3	94	4.95	1.075
1	74	7.49	0.91
1	54	10.03	0.74
1	44	11.3	0.665
1	34	12.57	0.61
1	24	13.84	0.56
1	14	15.11	0.52
1	04	16.38	0.48
1	994	17.65	0.445
1	984	18.92	0.415
1	974	20.19	0.39
1	964	21.46	0.365
1	954	22.73	0.34
1	944	24.0	0.32
1	934	25.27	0.30
1	924	26.54	0.28
1	914	27.81	0.26
1	904	29.08	0.22
1	894	30.35	0.07 BOTTOM
		Depth. 30.35 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 8/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% CaO

Atm.: H.P. Ar.

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.07Ω RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.5	———
4.95	———	1.075	———
7.49	———	0.91	———
10.03	0.305	0.74	0.455
11.3	0.284	0.665	0.477
12.57	0.265	0.61	0.491
13.84	0.247	0.56	0.504
15.11	0.230	0.52	0.511
16.38	0.214	0.48	0.522
17.65	0.199	0.445	0.530
18.92	0.186	0.415	0.539
20.19	0.174	0.39	0.544
21.46	0.164	0.365	0.556
22.73	0.154	0.34	0.570
24.0	0.146	0.32	0.584
25.27	0.139	0.30	0.604
26.54	———	0.28	———
27.81	———	0.26	———
29.08	———	0.22	———

wide – 0.530 ± 0.033

narrow – 0.559 ± 0.019

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 8/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar (gettered)

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt.% CaO

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG. (#1+2 only)
	RUN# 1	RUN# 2	RUN# 3	
0.0	3.0	3.0	2.5	3.0
4.95	1.175	1.2	1.075	1.188
7.49	0.93	0.96	0.91	0.945
10.03	0.76	0.78	0.74	0.770
11.3	0.70	0.71	0.665	0.705
12.57	0.64	0.65	0.61	0.645
13.84	0.59	0.605	0.56	0.598
15.11	0.55	0.56	0.52	0.555
16.38	0.51	0.525	0.48	0.518
17.65	0.48	0.49	0.445	0.485
18.92	0.45	0.46	0.415	0.455
20.19	0.42	0.435	0.39	0.428
21.46	0.40	0.41	0.365	0.405
22.73	0.38	0.39	0.34	0.385
24.0	0.355	0.37	0.32	0.363
25.27	0.335	0.35	0.30	0.343
26.54	0.315	0.325	0.28	0.320
27.81	0.285	0.30	0.26	0.293
29.08	0.25	0.265	0.22	0.258
30.35	— 0.07 —	— 0.07 —	— 0.07 —	— 0.07 Rext.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 8/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt.% CaO

Atm.: H.P. Ar (gettered)

TEMPERATURE: 1300 °C ± 5°

$r_{ext.}$ = 0.07 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (1+2).	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	3.0	—
4.95	—	1.188	—
7.49	—	0.945	—
10.03	0.305	0.770	0.436
11.3	0.284	0.705	0.447
12.57	0.265	0.645	0.461
13.84	0.247	0.598	0.468
15.11	0.230	0.555	0.474
16.38	0.214	0.518	0.478
17.65	0.199	0.485	0.479
18.92	0.186	0.455	0.483
20.19	0.174	0.428	0.486
21.46	0.164	0.405	0.489
22.73	0.154	0.385	0.489
24.0	0.146	0.363	0.498
25.27	0.139	0.343	0.509.
26.54	—	0.320	—
27.81	—	0.293	—
29.08	—	0.258	—

wide – 0.477 ± 0.014

narrow – 0.489 ± 0.006.

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 8/87

Atm.: H.P. Ar.

SUMMARY OF RESISTANCE MEASUREMENTS:

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5wt.% CaO

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	3.0	3.0	2.5	2.83
4.95	1.175	1.2	1.075	1.15
7.49	0.93	0.96	0.91	0.933
10.03	0.76	0.78	0.74	0.760
11.3	0.70	0.71	0.665	0.692
12.57	0.64	0.65	0.61	0.633
13.84	0.59	0.605	0.56	0.585
15.11	0.55	0.56	0.52	0.543
16.38	0.51	0.525	0.48	0.505
17.65	0.48	0.49	0.445	0.472
18.92	0.45	0.46	0.415	0.442
20.19	0.42	0.435	0.39	0.415
21.46	0.40	0.41	0.365	0.392
22.73	0.38	0.39	0.34	0.370
24.0	0.355	0.37	0.32	0.348
25.27	0.335	0.35	0.30	0.328
26.54	0.315	0.325	0.28	0.307
27.81	0.285	0.30	0.26	0.282
29.08	0.25	0.265	0.22	0.245
30.35 —	— 0.07 —	— 0.07 —	— 0.07 —	— 0.07 Rext.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: $0.85\ Fe/SiO_2$ with 5wt.% CaO.

TEMPERATURE: 1300°C ± 5°

DATE: DEC. 8/87

Atm.: H.P. Ar.

$r_{ext.}$ = 0.07 Ω

DEPTH (mm)	CELL CONSTANT (cm⁻¹)	RESISTANCE (ohm)	CONDUCTIVITY (ohm⁻¹.cm⁻¹)
0.0	—	2.83	—
4.95	—	1.15	—
7.49	—	0.933	—
10.03	0.305	0.760	0.442
11.3	0.284	0.692	0.457
12.57	0.265	0.633	0.471
13.84	0.247	0.585	0.480
15.11	0.230	0.543	0.486
16.38	0.214	0.505	0.492
17.65	0.199	0.472	0.495
18.92	0.186	0.442	0.500
20.19	0.174	0.415	0.504
21.46	0.164	0.392	0.509
22.73	0.154	0.370	0.513
24.0	0.146	0.348	0.525
25.27	0.139	0.328	0.539
26.54	—	0.307	—
27.81	—	0.282	—
29.08	—	0.245	—

wide – ~~0.400 ± 0.014~~ 0.494 ± 0.020

narrow – ~~0.402 ±~~ 0.570 ± 0.010

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10 wt.% CaO addition DATE: DEC. 20/87

Additions made to sample:

90 g as-received + 4.11 g SiO_2 + 9.0 g CaO

Atm.: H.P. Ar (gettered)

Total wt. of sample: 103.11 g

Total wt. w/crucible: init.- 152.47
finl.- 151.54

RUN#: 1 TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	104	0.0	2.9
3	65	4.95	1.15
1	45	7.49	0.94
1	25	10.03	0.78
1	15	11.3	0.715
1	05	12.57	0.665
1	995	13.84	0.62
1	985	15.11	0.58
1	975	16.38	0.545
1	965	17.65	0.51
1	955	18.92	0.48
1	945	20.19	0.455
1	935	21.46	0.43
1	925	22.73	0.40
1	915	24.0	0.38
1	905	25.27	0.355
1	895	26.54	0.325
1	885	27.81	0.245
1	879	BOTTOM ~~29.08~~	ε 0.06
		Depth. 28.6 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 20/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10% CaO

Atm.: H.P. Ar.

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1} \cdot cm^{-1}$)
0.0	—	2.9	—
4.95	—	1.15	—
7.49	—	0.94	—
10.03	0.305	0.78	0.424
11.3	0.284	0.715	0.434
12.57	0.265	0.665	0.438
13.84	0.247	0.62	0.441
15.11	0.230	0.58	0.442
16.38	0.214	0.545	0.441
17.65	0.199	0.51	0.442
18.92	0.186	0.48	0.443
20.19	0.174	0.455	0.441
21.46	0.164	0.43	0.443
22.73	0.154	0.40	0.453
24.0	0.146	0.38	0.456
25.27	0.139	0.355	0.471
26.54	—	0.325	—
27.81	—	0.245	—
29.08	—	—	—

wide – 0.443 ± 0.006

narrow – 0.442 ± 0.0008

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10% CaO

DATE: DEC. 20/87

Additions made to sample:

90g as-received + 4.11g SiO_2 + 9.0g CaO

Atm.: A.P. Ar (gettered)

Total wt. of sample: 103.11g

Total wt. w/crucible: init.- 152.47g
finl.- 151.54g

RUN#: 2

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	105	0.0	3.0
3	66	4.95	1.2
1	46	7.49	0.95
1	26	10.03	~~76~~ 0.77
1	16	11.3	0.70
1	06	12.57	0.64
1	996	13.84	0.60
1	986	15.11	0.56
1	976	16.38	0.52
1	966	17.65	0.50
1	956	18.92	0.46
1	946	20.19	0.44
1	936	21.46	0.415
1	926	22.73	0.385
1	916	24.0	0.36
1	906	25.27	0.34
1	896	26.54	0.305
1 (0.3)	886	27.81	0.25 (0.285)
1	876	BOTTOM ~~29.08~~	0.06
		Depth. 29.08 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10% CaO

TEMPERATURE: 1250°c ± 5°

DATE: DEC. 20/87

Atm.: H.P. Ar

$r_{ext.}$ = 0.06Ω

RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	3.0	———
4.95	———	1.2	———
7.49	———	0.95	———
10.03	0.305	0.77	0.430
11.3	0.284	0.70	0.444
12.57	0.265	0.64	0.457
13.84	0.247	0.60	0.457
15.11	0.230	0.56	0.460
16.38	0.214	0.52	0.465
17.65	0.199	0.50	0.452
18.92	0.186	0.46	0.465
20.19	0.174	0.44	0.447
21.46	0.164	0.415	0.462
22.73	0.154	0.385	0.474
24.0	0.146	0.36	0.487
25.27	0.139	0.34	0.496
26.54	———	0.305	———
27.81	———	0.25	———
29.08	———	———	———

wide – 0.461 ± 0.012

narrow – 0.458 ± 0.008

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10 wt.% CaO

DATE: DEC. 20/87

Additions made to sample:

90 g as-received + 4.11 g SiO_2 + 9.0 g CaO

Atm.: H.P. Ar (gettered)

Total wt. of sample: 103.11 g

Total wt. w/crucible: init. - 152.47 g
finl. - 151.54

RUN#: 3

TEMPERATURE: 1250 °C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	104	0.0	3.4
3	65	4.95	1.25
3	45	7.49	1.0
1	25	10.03	0.82
1	15	11.3	0.755
1	05	12.57	0.70
1	995	13.84	0.65
1	985	15.11	0.60
1	975	16.38	0.56
1	965	17.65	0.53
1	955	18.92	0.50
1	945	20.19	0.47
1	935	21.46	0.445
1	925	22.73	0.42
1	915	24.0	0.40
1	905	25.27	0.37
1	895	26.54	0.34
1	885	27.81	0.28
1	878	BOTTOM ~~29.08~~	0.06
		Depth. 28.7 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 20/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10% CaO.

Atm.: H.P. Ar.

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω

RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	3.4	—
4.95	—	1.25	—
7.49	—	1.0	—
10.03	0.305	0.82	0.401
11.3	0.284	0.755	0.409
12.57	0.265	0.70	0.414
13.84	0.247	0.65	0.419
15.11	0.230	0.60	0.426
16.38	0.214	0.56	0.428
17.65	0.199	0.53	0.423
18.92	0.186	0.50	0.423
20.19	0.174	0.47	0.424
21.46	0.164	0.445	0.426
22.73	0.154	0.42	0.428
24.0	0.146	0.40	0.429
25.27	0.139	0.37	0.448
26.54	—	0.34	—
27.81	—	0.28	—
29.08	—	—	—

wide – 0.423 ± 0.006

narrow – 0.425 ± 0.002

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 20/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: U.P. Ar (gettered)

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10 wt.% CaO

TEMPERATURE: 1250°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.9	3.0	3.4	3.10
4.95	1.15	1.2	1.25	1.20
7.49	0.94	0.95	1.0	0.963
10.03	0.78	0.77	0.82	0.790
11.3	0.715	0.70	0.755	0.723
12.57	0.665	0.64	0.70	0.668
13.84	0.62	0.60	0.65	0.623
15.11	0.58	0.56	0.60	0.580
16.38	0.545	0.52	0.56	0.542
17.65	0.51	0.50	0.53	0.513
18.92	0.48	0.46	0.50	0.480
20.19	0.455	0.44	0.47	0.455
21.46	0.43	0.415	0.445	0.430
22.73	0.40	0.385	0.42	0.402
24.0	0.38	0.36	0.40	0.380
25.27	0.355	0.34	0.37	0.355
26.54	0.325	0.305	0.34	0.323
27.81	0.245	0.25	0.28	0.258
~~29.08~~	Rext. 0.06	Rext. 0.06	Rext. 0.06	0.06

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10wt.% CaO addition.

DATE: DEC. 20/87

Atm.: H.P. Ar (gettered)

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	3.10	———
4.95	———	1.20	———
7.49	———	0.963	———
10.03	0.305	0.790	0.418
11.3	0.284	0.723	0.428
12.57	0.265	0.668	0.436
13.84	0.247	0.623	0.439
15.11	0.230	0.580	0.442
16.38	0.214	0.542	0.444
17.65	0.199	0.513	0.439
18.92	0.186	0.480	0.443
20.19	0.174	0.455	0.441
21.46	0.164	0.430	0.443
22.73	0.154	0.402	0.450
24.0	0.146	0.380	0.456
25.27	0.139	0.355	0.471
26.54	———	0.323	———
27.81	———	0.258	———
29.08	———	———	———

wide – 0.442 ± 0.007

narrow – 0.442 ± 0.002

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10wt.% CaO

DATE: DEC. 20/87

Additions made to sample:

Atm.: A.P. Ar (gettered).

90g as-received + 4.11g SiO_2 + 9.0g CaO

Total wt. of sample: 103.11g

Total wt. w/crucible: init.- 152.47g
finl.- 151.54

RUN#: 1

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	103	0.0	2.45
1	64	4.95	1.0
1	44	7.49	0.75
1	24	10.03	0.61
1	14	11.3	0.56
1	04	12.57	0.505
1	994	13.84	0.475
1	984	15.11	0.44
1	974	16.38	0.41
1	964	17.65	0.39
1	954	18.92	0.36
1	944	20.19	0.34
1	934	21.46	0.32
1	924	22.73	0.29
1	914	24.0	0.30
1	904	25.27	0.28
1	894	26.54	0.255
1 (0.3)	884	27.81	0.155 (0.20)
1 (0.3)	878	BOTTOM ~~29.08~~	0.02 (0.06)
		Depth. 28.6 mm.	

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10% CaO

TEMPERATURE: 1300°C ± 5°

DATE: DEC. 20/87

Atm.: HP. Ar

$r_{ext.}$ = 0.02 Ω

RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.45	—
4.95	—	1.0	—
7.49	—	0.75	—
10.03	0.305	0.61	0.517
11.3	0.284	0.56	0.526
12.57	0.265	0.505	0.546
13.84	0.247	0.475	0.543
15.11	0.230	0.44	0.548
16.38	0.214	0.41	0.549
17.65	0.199	0.39	0.538
18.92	0.186	0.36	0.547
20.19	0.174	0.34	0.544
21.46	0.164	0.32	0.547
22.73	0.154	0.29	0.570
24.0	0.146	0.30	0.521
25.27	0.139	0.28	0.535
26.54	—	0.255	—
27.81	—	0.155	—
29.08	—	—	—

wide – 0.544 ± 0.013

narrow – 0.546 ± 0.0017

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10 wt.% CaO

DATE: DEC. 20/87

Additions made to sample:

90 g as-received + 4.11 g SiO_2 + 9.0 g CaO

Atm.: H.P. Ar (gettered)

Total wt. of sample: 103.11 g

Total wt. w/crucible: init.- 152.47 g
finl.- 151.54

RUN#: 2

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	103	0.0	2.65
3	64	4.95	0.95
1	44	7.49	0.78
1	24	10.03	0.65
1	14	11.3	0.60
1	04	12.57	0.55
1	994	13.84	0.50
1	984	15.11	0.48
1	974	16.38	0.45
1	964	17.65	0.42
1	954	18.92	0.40
1	944	20.19	0.38
1	934	21.46	0.355
1	924	22.73	0.33
1	914	24.0	0.315
1	904	25.27	0.29
1	894	26.54	0.27
1	884	27.81	0.20
1 (0.3)	878 BOTTOM	~~29.08~~	0.025 (0.06)
		Depth. 28.6 mm.	

CONDUCTIVITY CALCULATION:

DATE: DEC. 20/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10% CaO

Atm.: HP. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.025Ω RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.65	———
4.95	———	0.95	———
7.49	———	0.78	———
10.03	0.305	0.65	0.488
11.3	0.284	0.60	0.494
12.57	0.265	0.55	0.505
13.84	0.247	0.50	0.520
15.11	0.230	0.48	0.505
16.38	0.214	0.45	0.504
17.65	0.199	0.42	0.504
18.92	0.186	0.40	0.496
20.19	0.174	0.38	0.490
21.46	0.164	0.355	0.497
22.73	0.154	0.33	0.505
24.0	0.146	0.315	0.503
25.27	0.139	0.29	0.525
26.54	———	0.27	———
27.81	———	0.20	———
29.08	———	———	———

wide - 0.502 ± 0.008

narrow - 0.498 ± 0.006

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10 wt.% CaO

DATE: DEC. 20/87

Additions made to sample:

90g as-received + 4.11g SiO_2 + 9.0g CaO

Atm.: H.P. Ar (gettered)

Total wt. of sample: 103.11g

Total wt. w/crucible: init.- 152.47g

finl.- 151.54g

RUN#: 3

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	103	0.0	2.8
3	64	4.95	1.0
1	44	7.49	0.83
1	24	10.03	0.69
1	14	11.3	0.625
1	04	12.57	0.585
1	994	13.84	0.54
1	984	15.11	0.505
1	974	16.38	0.475
1	964	17.65	0.45
1	954	18.92	0.43
1	944	20.19	0.40
1	934	21.46	0.38
1	924	22.73	0.365
1	914	24.0	0.34
1	904	25.27	0.32
1	894	26.54	0.30
1	884	27.81	0.235
1 (0.3	878	29.08	0.05 (0.06)
		Depth. 28.6 mm.	

CONDUCTIVITY CALCULATION:

DATE: DEC. 20/87

SLAG SAMPLE: 0.85 Fe/SiO$_2$ with 10% CaO

Atm.: H.P. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.05Ω

RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY (ohm^{-1}.cm^{-1})
0.0	———	2.8	———
4.95	———	1.0	———
7.49	———	0.83	———
10.03	0.305	0.69	0.477
11.3	0.284	0.625	0.494
12.57	0.265	0.585	0.495
13.84	0.247	0.54	0.504
15.11	0.230	0.505	0.505
16.38	0.214	0.475	0.504
17.65	0.199	0.45	0.498
18.92	0.186	0.43	0.489
20.19	0.174	0.40	0.497
21.46	0.164	0.38	0.497
22.73	0.154	0.365	0.489
24.0	0.146	0.34	0.503
25.27	0.139	0.32	0.515
26.54	———	0.30	———
27.81	———	0.235	———
29.08	———	———	———

wide – 0.498 ± 0.006

narrow – 0.495 ± 0.006

SLAG CONDUCTIVITY DETERMINATION

SUMMARY OF RESISTANCE MEASUREMENTS:

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10% CaO

TEMPERATURE: 1300°C ± 5°

DATE: DEC. 20/87 X

Atm.: H.P. Ar

DEPTH (mm)	RESISTANCE (ohms)			AVG. (#2+3)
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.45	2.65	2.8	2.725
4.95	1.0	0.95	1.0	0.975
7.49	0.75	0.78	0.83	0.805
10.03	0.61	0.65	0.69	0.670
11.3	0.56	0.60	0.625	0.613
12.57	0.505	0.55	0.585	0.568
13.84	0.475	0.50	0.54	0.520
15.11	0.44	0.48	0.505	0.493
16.38	0.41	0.45	0.475	~~0.463~~ 0.463
17.65	0.39	0.42	0.45	0.435
18.92	0.36	0.40	0.43	0.415
20.19	0.34	0.38	0.40	0.390
21.46	0.32	0.355	0.38	0.368
22.73	0.29	0.33	0.365	0.348
24.0	0.30	0.315	0.34	0.328
25.27	0.28	0.29	0.32	0.305
26.54	0.255	0.27	0.30	0.285
27.81	0.155	0.20	0.235	0.218
29.08	Rext 0.02 —	Rext 0.025 —	Rext. 0.05 —	0.0375 Rext.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 20/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10% CaO

Atm.: HP. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.0375 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (2+3) only	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.725	—
4.95	—	0.975	—
7.49	—	0.805	—
10.03	0.305	0.670	0.482
11.3	0.284	0.613	0.493
12.57	0.265	0.568	[illegible] 0.500
13.84	0.247	0.520	0.512
15.11	0.230	0.493	0.505
16.38	0.214	0.463	0.503
17.65	0.199	0.435	0.501
18.92	0.186	0.415	0.493
20.19	0.174	0.390	0.494
21.46	0.164	0.368	0.496
22.73	0.154	0.348	0.496
24.0	0.146	0.328	0.503
25.27	0.139	0.305	0.520
26.54	—	0.285	—
27.81	—	0.218	—
29.08	—	—	—

wide. – 0.500 ± 0.006

narrow – 0.496 ± 0.004.

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 20/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: HP. Ar.

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10% CaO

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.45	2.65	2.8	2.633
4.95	1.0	0.95	1.0	0.983
7.49	0.75	0.78	0.83	0.787
10.03	0.61	0.65	0.69	0.650
11.3	0.56	0.60	0.625	0.595
12.57	0.505	0.55	0.585	0.547
13.84	0.475	0.50	0.54	0.505
15.11	0.44	0.48	0.505	0.475
16.38	0.41	0.45	0.475	0.445
17.65	0.39	0.42	0.45	0.420
18.92	0.36	0.40	0.43	0.397
20.19	0.34	0.38	0.40	0.373
21.46	0.32	0.355	0.38	0.352
22.73	0.29	0.33	0.365	0.328
24.0	0.30	0.315	0.34	0.318
25.27	0.28	0.29	0.32	0.297
26.54	0.255	0.27	0.30	0.275
27.81	0.155	0.20	0.235	0.197
29.08	Rext 0.02	Rext. 0.025	Rext. 0.05	0.032 Rext.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 20/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10% CaO

Atm.: HP. Ar.

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.032 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.633	—
4.95	—	0.983	—
7.49	—	0.787	—
10.03	0.305	0.650	0.494
11.3	0.284	0.595	0.504
12.57	0.265	0.547	0.515
13.84	0.247	0.505	0.522
15.11	0.230	0.475	0.519
16.38	0.214	0.445	0.518
17.65	0.199	0.420	0.513
18.92	0.186	0.397	~~0.50~~ 0.510
20.19	0.174	0.373	0.510
21.46	0.164	0.352	0.513
22.73	0.154	0.328	0.520
24.0	0.146	0.318	0.510
25.27	0.139	0.297	0.525
26.54	—	0.275	—
27.81	—	0.197	—
29.08	—	—	—

wide – 0.514 ± 0.005

narrow – 0.513 ± 0.004

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15 wt.% CaO addition DATE: DEC. 21/87

Additions made to sample: Atm.: H.P. Ar (gettered)

90 g as-received + 4.11 g SiO_2 + 14.12 g CaO

Total wt. of sample: 108.23 g Total wt. w/crucible: init.- 155.38 g

fin1.- 153.84 g

RUN#: 1 TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	121	0.0	2.85
3	82	4.95	1.175
1	62	7.49	0.955
1	42	10.03	0.79
1	32	11.3	0.72
1	22	12.57	0.67
1	12	13.84	0.62
1	02	15.11	0.58
1	992	16.38	0.545
1	982	17.65	0.51
1	972	18.92	0.48
1	962	20.19	0.46
1	952	21.46	0.43
1	942	22.73	0.41
1	932	24.0	0.39
1	922	25.27	0.365
1	912	26.54	0.34
1	902	27.81	0.30
1	892	29.08	0.11
1	886	BOTTOM.	0.04
		Depth 29.8 mm	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 21/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15% CaO

Atm.: H.P. Ar

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.04 Ω **RUN#:** 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.85	———
4.95	———	1.175	———
7.49	———	0.955	———
10.03	0.305	0.79	0.407
11.3	0.284	0.72	0.418
12.57	0.265	0.67	0.421
13.84	0.247	0.62	0.426
15.11	0.230	0.58	0.426
16.38	0.214	0.545	0.424
17.65	0.199	0.51	0.424
18.92	0.186	0.48	0.423
20.19	0.174	0.46	0.414
21.46	0.164	0.43	0.421
22.73	0.154	0.41	0.416
24.0	0.146	0.39	0.417
25.27	0.139	0.365	0.428
26.54	———	0.34	———
27.81	———	0.30	———
29.08	———	0.11	———

wide - 0.421 ± 0.004

narrow - 0.423 ± 0.002

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15 wt.% CaO

DATE: DEC. 21/87

Additions made to sample:

90 g as-received + 4.11 g SiO_2 + 14.12 g CaO

Atm.: H.P. Ar (gettered)

Total wt. of sample: 108.23 g

Total wt. w/crucible: init.- 155.38 g

finl.- 153.84

RUN#: 2

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	120	0.0	3.0
3	81	4.95	1.2
1	61	7.49	0.98
1	41	10.03	0.80
1	31	11.3	0.735
1	21	12.57	0.68
1	11	13.84	0.635
1	01	15.11	0.59
1	991	16.38	0.555
1	981	17.65	0.525
1	971	18.92	0.49
1	961	20.19	0.46
1	951	21.46	0.44
1	941	22.73	0.42
1	931	24.0	0.40
1	921	25.27	0.37
1	911	26.54	0.34
1	901	27.81	0.305
1	891	29.08	0.045
1	886	BOTTOM.	0.04
		Depth 29.8 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 21/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15% CaO.

Atm.: H.P. Ar.

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.04 Ω

RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	3.0	—
4.95	—	1.2	—
7.49	—	0.98	—
10.03	0.305	0.80	0.401
11.3	0.284	0.735	0.409
12.57	0.265	0.68	0.414
13.84	0.247	0.635	0.415
15.11	0.230	0.59	0.418
16.38	0.214	0.555	0.416
17.65	0.199	0.525	0.410
18.92	0.186	0.49	0.413
20.19	0.174	0.46	0.414
21.46	0.164	0.44	0.410
22.73	0.154	0.42	0.405
24.0	0.146	0.40	0.406
25.27	0.139	0.37	0.421
26.54	—	0.34	—
27.81	—	0.305	—
29.08	—	0.045	—

wide – 0.412 ± 0.004

narrow – 0.414 ± 0.003

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO$_2$ with 15wt.% CaO

DATE: DEC. 21/87

Additions made to sample:

90g as-received + 4.11g SiO$_2$ + 14.12g CaO

Atm.: H.P. Ar (Gettered)

Total wt. of sample: 108.23g

Total wt. w/crucible: init.- 155.38g

finl.- 153.84

RUN#: 3

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
10	119	0.0	2.75
3	80	4.95	1.15
1	60	7.49	0.95
1	40	10.03	0.78
1	30	11.3	0.71
1	20	12.57	0.66
1	10	13.84	0.61
1	0	15.11	0.57
1	990	16.38	0.53
1	980	17.65	0.50
1	970	18.92	0.475
1	960	20.19	0.445
1	950	21.46	0.42
1	940	22.73	0.395
1	930	24.0	0.37
1	920	25.27	0.35
1	910	26.54	0.32
1	900	27.81	0.29
1	890	29.08	0.045
1	886	BOTTOM	0.04
		Depth. 29.6 mm	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 21/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15% CaO

Atm.: H.P. Ar.

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.04 Ω

RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.75	—
4.95	—	1.15	—
7.49	—	0.95	—
10.03	0.305	0.78	0.412
11.3	0.284	0.71	0.424
12.57	0.265	0.66	0.427
13.84	0.247	0.61	0.433
15.11	0.230	0.57	0.433
16.38	0.214	0.53	0.437
17.65	0.199	0.50	0.433
18.92	0.186	0.475	0.423
20.19	0.174	0.445	0.430
21.46	0.164	0.42	0.432
22.73	0.154	0.395	0.434
24.0	0.146	0.37	0.442
25.27	0.139	0.35	0.448
26.54	—	0.32	—
27.81	—	0.29	—
29.08	—	0.045	—

wide – 0.432 ± 0.006

narrow – 0.431 ± 0.005

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 21/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar (gettered)

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15 wt.% CaO

TEMPERATURE: 1250°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.85	3.0	2.75	2.867
4.95	1.175	1.2	1.15	1.175
7.49	0.955	0.98	0.95	0.962
10.03	0.79	0.80	0.78	0.790
11.3	0.72	0.735	0.71	0.722
12.57	0.67	0.68	0.66	0.670
13.84	0.62	0.635	0.61	0.622
15.11	0.58	0.59	0.57	0.580
16.38	0.545	0.555	0.53	0.543
17.65	0.51	0.525	0.50	0.512
18.92	0.48	0.49	0.475	0.482
20.19	0.46	0.46	0.445	0.455
21.46	0.43	0.44	0.42	0.430
22.73	0.41	0.42	0.395	0.408
24.0	0.39	0.40	0.37	0.387
25.27	0.365	0.37	0.35	0.362
26.54	0.34	0.34	0.32	0.333
27.81	0.30	0.305	0.29	0.298
29.08	0.11	0.045 <- ?	0.045	—
	Rext. 0.04	Rext. 0.04	Rext. 0.04	Rext. 0.04

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION: DATE: DEC. 21/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15 wt.% CaO Atm.: H.P. Ar (Gettered)

TEMPERATURE: 1250°C ± 5° $r_{ext.}$ = 0.04 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.867	—
4.95	—	1.175	—
7.49	—	0.962	—
10.03	0.305	0.790	0.407
11.3	0.284	0.722	0.416
12.57	0.265	0.670	0.421
13.84	0.247	0.622	0.424
15.11	0.230	0.580	0.426
16.38	0.214	0.543	0.425
17.65	0.199	0.512	0.422
18.92	0.186	0.482	0.421
20.19	0.174	0.455	0.419
21.46	0.164	0.430	0.421
22.73	0.154	0.408	0.418
24.0	0.146	0.387	0.421
25.27	0.139	0.362	0.432
26.54	—	0.333	—
27.81	—	0.298	—
29.08	—	—	—

wide - 0.421 ± 0.003

narrow - 0.423 ± 0.003

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 • Fe/SiO_2 with 15wt% CaO

DATE: DEC. 21/87

Additions made to sample:

90g as-received + 4.11g SiO_2 + 14.12g CaO

Atm.: H.P. Ar (gettered)

Total wt. of sample: 108.23g

Total wt. w/crucible: init.- 155.38g
finl.- 153.84

RUN#: 1

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	120	0.0	2.9
3	81	4.95	0.95
1	61	7.49	0.80
1	41	10.03	0.655
1	31	11.3	0.595
1	21	12.57	0.55
1	11	13.84	0.515
1	01	15.11	0.485
1	991	16.38	0.45
1	981	17.65	0.425
1	971	18.92	0.40
1	961	20.19	0.38
1	951	21.46	0.36
1	941	22.73	0.34
1	931	24.0	0.32
1	921	25.27	0.30
1	911	26.54	0.28
1	901	27.81	0.255
1	891	29.08	0.14
1	886	BOTTOM	0.04
		Depth 29.7 mm	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 21/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15% CaO

Atm.: H.P. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.04 Ω

RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.9	—
4.95	—	0.95	—
7.49	—	0.80	—
10.03	0.305	0.655	0.496
11.3	0.284	0.595	0.512
12.57	0.265	0.55	0.520
13.84	0.247	0.515	0.520
15.11	0.230	0.485	0.517
16.38	0.214	0.45	0.522
17.65	0.199	0.425	0.517
18.92	0.186	0.40	0.517
20.19	0.174	0.38	0.512
21.46	0.164	0.36	0.513
22.73	0.154	0.34	0.513
24.0	0.146	0.32	0.521
25.27	0.139	0.30	0.535
26.54	—	0.28	—
27.81	—	0.255	—
29.08	—	0.14	—

wide – 0.517 ± 0.004

narrow – 0.515 ± 0.004

X

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15 wt.% CaO

DATE: DEC. 21/87

Additions made to sample:

90 g as-received + 4.11 g SiO_2 + 14.12 g CaO

Atm.: H.P. Ar (gettered)

Total wt. of sample: 108.23 g

Total wt. w/crucible: init.- 155.38 g
finl.- 153.84 g

RUN#: 2

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	119	0.0	2.9
3	80	4.95	1.05
1	60	7.49	0.83
1	40	10.03	0.685
1	30	11.3	0.635
1	20	12.57	0.58
1	10	13.84	0.545
1	0	15.11	0.505
1	990	16.38	0.475
1	980	17.65	0.45
1	970	18.92	0.425
1	960	20.19	0.40
1	950	21.46	0.38
1	940	22.73	0.36
1	930	24.0	0.34
1	920	25.27	0.32
1	910	26.54	0.30
1	900	27.81	0.27
1	890	29.08	0.06
1	886.	BOTTOM	0.06
		Depth 29.6 mm	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 21/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15% CaO

Atm.: H.P. Ar.

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.06 Ω

RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.9	———
4.95	———	1.05	———
7.49	———	0.83	———
10.03	0.305	0.685	0.488
11.3	0.284	0.635	0.494
12.57	0.265	0.58	0.510
13.84	0.247	0.545	0.509
15.11	0.230	0.505	0.517
16.38	0.214	0.475	0.516
17.65	0.199	0.45	0.510
18.92	0.186	0.425	0.510
20.19	0.174	0.40	0.512
21.46	0.164	0.38	0.513
22.73	0.154	0.36	0.513
24.0	0.146	0.34	0.521
25.27	0.139	0.32	0.535
26.54	———	0.30	———
27.81	———	0.27	———
29.08	———	0.06	———

wide – 0.511 ± 0.007

narrow – 0.514 ± 0.004

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15wt.% CaO

DATE: DEC. 21/87

Additions made to sample:

90g as-received + 4.11g SiO_2 + 14.12g CaO

Atm.: H.P. Ar (gettered)

Total wt. of sample: 108.23g

Total wt. w/crucible: init.- 155.38g
finl.- 153.84g

RUN#: 3

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	119	0.0	2.9
3	80	4.95	1.05
1	60	7.49	0.84
1	40	10.03	0.69
1	30	11.3	0.64
1	20	12.57	0.595
1	10	13.84	0.55
1	0	15.11	0.515
1	990	16.38	0.48
1	980	17.65	0.455
1	970	18.92	0.43
1	960	20.19	0.41
1	950	21.46	0.385
1	940	22.73	0.365
1	930	24.0	0.35
1	920	25.27	0.33
1	910	26.54	0.305
1	900	27.81	0.28
1	890	29.08	0.06
1	886	BOTTOM	Rext. 0.06
		Depth. 29.6 mm	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 21/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15% CaO

Atm.: H.P. Ar.

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.06 Ω

RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.9	———
4.95	———	1.05	———
7.49	———	0.84	———
10.03	0.305	0.69	0.484
11.3	0.284	0.64	0.490
12.57	0.265	0.595	0.495
13.84	0.247	0.55	0.504
15.11	0.230	0.515	0.505
16.38	0.214	0.48	0.510
17.65	0.199	0.455	0.504
18.92	0.186	0.43	0.503
20.19	0.174	0.41	0.497
21.46	0.164	0.385	0.505
22.73	0.154	0.365	0.505
24.0	0.146	0.35	0.503
25.27	0.139	0.33	0.515
26.54	———	0.305	———
27.81	———	0.28	———
29.08	———	0.06	———

wide – 0.502 ± 0.006

narrow – 0.503 ± 0.003

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 21/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar (gettered)

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15wt.% CaO

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG. (#2+3 only)
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.9	2.9	2.9	2.90
4.95	0.95	1.05	1.05	1.05
7.49	0.80	0.83	0.84	0.835
10.03	0.655	0.685	0.69	0.688
11.3	0.595	0.635	0.64	0.638
12.57	0.55	0.58	0.595	0.588
13.84	0.515	0.545	0.55	0.548
15.11	0.485	0.505	0.515	0.510
16.38	0.45	0.475	0.48	0.478
17.65	0.425	0.45	0.455	0.453
18.92	0.40	0.425	0.43	0.428
20.19	0.38	0.40	0.41	0.405
21.46	0.36	0.38	0.385	0.383
22.73	0.34	0.36	0.365	0.363
24.0	0.32	0.34	0.35	0.345
25.27	0.30	0.32	0.33	0.325
26.54	0.28	0.30	0.305	0.303
27.81	0.255	0.27	0.28	0.275
29.08	0.14	0.06	0.06	—
	Rext. 0.04	Rext. 0.06	Rext. 0.06.	Rext. 0.06.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 21/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15 wt.% CaO

Atm.: H.P. Ar (gettered)

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.06 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (2+3)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.9	—
4.95	—	1.05	—
7.49	—	0.835	—
10.03	0.305	0.688	0.486
11.3	0.284	0.638	0.491
12.57	0.265	0.588	0.502
13.84	0.247	0.548	0.506
15.11	0.230	0.510	0.511
16.38	0.214	0.478	0.512
17.65	0.199	0.453	0.506
18.92	0.186	0.428	0.505
20.19	0.174	0.405	0.504
21.46	0.164	0.383	0.508
22.73	0.154	0.363	0.508
24.0	0.146	0.345	0.512
25.27	0.139	0.325	0.525
26.54	—	0.303	—
27.81	—	0.275	—
29.08	—	—	—

wide – 0.506 ± 0.006

narrow – 0.507 ± 0.003

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 21/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: HP. Ar

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15 wt.% CaO

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG. (#1+2)
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.9	2.9	2.9	2.90
4.95	0.95	1.05	1.05	1.00
7.49	0.80	0.83	0.84	0.815
10.03	0.655	0.685	0.69	0.670
11.3	0.595	0.635	0.64	0.615
12.57	0.55	0.58	0.595	0.565
13.84	0.515	0.545	0.55	0.530
15.11	0.485	0.505	0.515	0.495
16.38	0.45	0.475	0.48	0.463
17.65	0.425	0.45	0.455	0.438
18.92	0.40	0.425	0.43	0.413
20.19	0.38	0.40	0.41	0.390
21.46	0.36	0.38	0.385	0.370
22.73	0.34	0.36	0.365	0.350
24.0	0.32	0.34	0.35	0.330
25.27	0.30	0.32	0.33	0.310
26.54	0.28	0.30	0.305	0.290
27.81	0.255	0.27	0.28	0.263
29.08	0.14	0.06	0.06	———
	Rest. 0.04 —	Rest 0.06 —	Rest. 0.06 —	0.05 Rest.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION: DATE: DEC. 21/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15 wt.% CaO Atm.: Hp. Ar

TEMPERATURE: 1300°C ± 5° $r_{ext.}$ = 0.05 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (1+2)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.90	—
4.95	—	1.00	—
7.49	—	0.815	—
10.03	0.305	0.670	0.492
11.3	0.284	0.615	0.503
12.57	0.265	0.565	0.515
13.84	0.247	0.530	~~0.514~~ 0.515
15.11	0.230	0.495	0.517
16.38	0.214	0.463	0.518
17.65	0.199	0.438	0.513
18.92	0.186	0.413	0.512
20.19	0.174	0.390	0.512
21.46	0.164	0.370	0.513
22.73	0.154	0.350	0.513
24.0	0.146	0.330	0.521
25.27	0.139	0.310	0.535
26.54	—	0.290	—
27.81	—	0.263	—
29.08	—	—	—

wide – 0.514 ± 0.005

narrow – 0.514 ± 0.004.

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 21/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar.

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15wt.% CaO

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.9	2.9	2.9	2.90
4.95	0.95	1.05	1.05	1.017
7.49	0.80	0.83	0.84	0.823
10.03	0.655	0.685	0.69	0.677
11.3	0.595	0.635	0.64	0.623
12.57	0.55	0.58	0.595	0.575
13.84	0.515	0.545	0.55	0.537
15.11	0.485	0.505	0.515	0.502
16.38	0.45	0.475	0.48	0.468
17.65	0.425	0.45	0.455	0.443
18.92	0.40	0.425	0.43	0.418
20.19	0.38	0.40	0.41	0.397
21.46	0.36	0.38	0.385	0.375
22.73	0.34	0.36	0.365	0.355
24.0	0.32	0.34	0.35	0.337
25.27	0.30	0.32	0.33	0.317
26.54	0.28	0.30	0.305	0.295
27.81	0.255	0.27	0.28	0.268
29.08	0.14	0.06	0.06	0.087
	Rext. 0.04	Rext. 0.06	Rext. 0.06.	0.053 Rext.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 21/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15% CaO

Atm.: U.P. Ar.

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.053Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.90	—
4.95	—	1.017	—
7.49	—	0.823	—
10.03	0.305	0.677	0.489
11.3	0.284	0.623	0.498
12.57	0.265	0.575	0.508
13.84	0.247	0.537	0.510
15.11	0.230	0.502	0.512
16.38	0.214	0.468	0.516
17.65	0.199	0.443	0.510
18.92	0.186	0.418	0.510
20.19	0.174	0.397	0.506
21.46	0.164	0.375	0.509
22.73	0.154	0.355	0.510
24.0	0.146	0.337	0.514
25.27	0.139	0.317	0.527
26.54	—	0.295	—
27.81	—	0.268	—
29.08	—	0.087	—

wide – 0.509 ± 0.004

narrow – 0.510 ± 0.003

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.95 Fe/SiO_2

DATE: DEC. 9/87

Additions made to sample:

100g as-received + 0.13g SiO_2

Atm.: H.P. Ar (gettered).

Total wt. of sample: 100.13g

Total wt. w/crucible: init.- 147.53g
finl.- 147.49g

RUN#: 1

TEMPERATURE: ~~120~~ 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	106	0.0	2.15
1	67	4.95	0.98
1	47	7.49	0.77
1	27	10.03	0.63
1	17	11.3	0.575
1	07	12.57	0.53
1	997	13.84	0.495
1	987	15.11	0.46
1	977	16.38	0.43
1	967	17.65	0.405
1	957	18.92	0.38
1	947	20.19	0.36
1	937	21.46	0.34
1	927	22.73	0.32
1	917	24.0	0.29 ~~[illegible]~~
1 (0.3)	907	25.27	0.26 (0.29)
1 (0.3)	897	BOTTOM. 26.54	0.03 (0.065)
1 (0.3)	~~887~~	~~27.81~~	
		~~29.08~~	
		Depth. 26.5 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 9/87

SLAG SAMPLE: 0.95 Fe/SiO_2

Atm.: H.P. Ar

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.03 Ω

RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.15	—
4.95	—	0.98	—
7.49	—	0.77	—
10.03	0.305	0.63	0.508
11.3	0.284	0.575	0.521
12.57	0.265	0.53	0.530
13.84	0.247	0.495	0.531
15.11	0.230	0.46	0.535
16.38	0.214	0.43	0.535
17.65	0.199	0.405	0.531
18.92	0.186	0.38	0.531
20.19	0.174	0.36	0.527
21.46	0.164	0.34	0.529
22.73	0.154	0.32	0.531
24.0	0.146	0.29	0.562
25.27	0.139	0.26	0.604
26.54	—	—	—
27.81	—	—	—
29.08	—	—	—

wide– 0.530 ± 0.004

narrow– 0.533 ± 0.002

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.95 Fe/SiO_2

DATE: DEC. 9/87

Additions made to sample:

100 g as-received + 0.13 g SiO_2

Atm.: H.P. Ar (gettered).

Total wt. of sample: 100.13 g

Total wt. w/crucible: init.- 147.53 g
finl.- 147.49 g

RUN#: 2

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	111	0.0	2.8
3	72	4.95	0.96
1	52	7.49	0.81
1	32	10.03	0.65
1	22	11.3	0.60
1	12	12.57	0.55
1	02	13.84	0.51
1	992	15.11	0.48
1	982	16.38	0.45
1	972	17.65	0.425
1	962	18.92	0.40
1	952	20.19	0.37
1	942	21.46	0.35
1	932	22.73	0.325
1	922	24.0	0.30
1	912	25.27	0.275 €
1 (0.3)	902	~~26.54~~ BOTTOM	0.03 (0.065)
		27.81	
		29.08	
		Depth. 26.5 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 9/87

SLAG SAMPLE: 0.95 Fe/SiO_2

Atm.: H.P. Ar.

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.03 Ω RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1} \cdot cm^{-1}$)
0.0	—	2.8	—
4.95	—	0.96	—
7.49	—	0.81	—
10.03	0.305	0.65	0.492
11.3	0.284	0.60	0.498
12.57	0.265	0.55	0.510
13.84	0.247	0.51	0.515
15.11	0.230	0.48	0.511
16.38	0.214	0.45	0.510
17.65	0.199	0.425	0.504
18.92	0.186	0.40	0.503
20.19	0.174	0.37	0.512
21.46	0.164	0.35	0.513
22.73	0.154	0.325	0.522
24.0	0.146	0.30	0.541
25.27	0.139	0.275	0.567
26.54	—	—	—
27.81	—	—	—
29.08	—	—	—

wide — 0.513 ± 0.011

narrow — 0.509 ± 0.005

X

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.95 Fe/SiO_2

DATE: DEC. 9/87

Additions made to sample:

100 g as-received + 0.13 g SiO_2

Atm.: H.P. Ar (Gettered).

Total wt. of sample: 100.13 g

Total wt. w/crucible: init.- 147.53 g

finl.- 147.49 g

RUN#: 3

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	112	0.0	2.90
3	73	4.95	1.0
1	53	7.49	0.84
1	33	10.03	0.69
1	23	11.3	0.63
1	13	12.57	0.58
1	03	13.84	0.54
1	993	15.11	0.50
1	983	16.38	0.47
1	973	17.65	0.44
1	963	18.92	0.41
1	953	20.19	0.385
1	943	21.46	0.36
1	933	22.73	0.34
1	923	24.0	0.32
1	913	25.27	0.29
1	903 BOTTOM.	~~26.54~~	0.03
		27.81	
		29.08	
		Depth. 26.5 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 9/87

SLAG SAMPLE: 0.95 Fe/SiO_2

Atm.: HP. Ar.

TEMPERATURE: 1250°C ±5°

$r_{ext.}$ = 0.03 Ω   RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.90	—
4.95	—	1.0	—
7.49	—	0.84	—
10.03	0.305	0.69	0.462
11.3	0.284	0.63	0.473
12.57	0.265	0.58	0.482
13.84	0.247	0.54	0.484
15.11	0.230	0.50	0.489
16.38	0.214	0.47	0.486
17.65	0.199	0.44	0.486
18.92	0.186	0.41	0.489
20.19	0.174	0.385	0.490
21.46	0.164	0.36	0.497
22.73	0.154	0.34	0.497
24.0	0.146	0.32	0.503
25.27	0.139	0.29	0.535
26.54	—	—	—
27.81	—	—	—
29.08	—	—	—

wide – 0.489 ± 0.008

narrow – 0.487 ± 0.002

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 9/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar

SLAG SAMPLE: 0.95 Fe/SiO_2

TEMPERATURE: 1250°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG. (#2+3)
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.15	2.8	2.90	2.85
4.95	0.98	0.96	1.0	0.980
7.49	0.77	0.81	0.84	0.825
10.03	0.63	0.65	0.69	0.670
11.3	0.575	0.60	0.63	0.615
12.57	0.53	0.55	0.58	0.565
13.84	0.495	0.51	0.54	0.525
15.11	0.46	0.48	0.50	0.490
16.38	0.43	0.45	0.47	0.460
17.65	0.405	0.425	0.44	0.433
18.92	0.38	0.40	0.41	0.405
20.19	0.36	0.37	0.385	0.378
21.46	0.34	0.35	0.36	0.355
22.73	0.32	0.325	0.34	0.333
24.0	0.29	0.30	0.32	0.310
25.27	0.26 (0.29)	0.275	0.29	0.283
26.54	0.03 (0.065)	0.03 (0.065)	0.03 —	0.03 Rept.
27.81				
29.08				

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 9/87

SLAG SAMPLE: 0.95 Fe/SiO_2

Atm.: HP. Ar.

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.03 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (#2-3).	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.85	—
4.95	—	0.980	—
7.49	—	0.825	—
10.03	0.305	0.670	0.477
11.3	0.284	0.615	0.485
12.57	0.265	0.565	0.495
13.84	0.247	0.525	0.499
15.11	0.230	0.490	0.500
16.38	0.214	0.460	0.498
17.65	0.199	0.433	0.494
18.92	0.186	0.405	0.496
20.19	0.174	0.378	0.500
21.46	0.164	0.355	0.505
22.73	0.154	0.333	0.508
24.0	0.146	0.310	0.521
25.27	0.139	0.283	0.549.
26.54	—	—	—
27.81	—	—	—
29.08	—	—	—

wide - 0.500 ± 0.009

narrow - 0.497 ± 0.002

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 9/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar (Gettered).

SLAG SAMPLE: 0.95 Fe/SiO$_2$

TEMPERATURE: 1250°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.15	2.8	2.90	2.62
4.95	0.98	0.96	1.0	0.980
7.49	0.77	0.81	0.84	0.807
10.03	0.63	0.65	0.69	0.647
11.3	0.575	0.60	0.63	0.602
12.57	0.53	0.55	0.58	0.553
13.84	0.495	0.51	0.54	0.515
15.11	0.46	0.48	0.50	0.480
16.38	0.43	0.45	0.47	0.450
17.65	0.405	0.425	0.44	0.423
18.92	0.38	0.40	0.41	0.397
20.19	0.36	0.37	0.385	0.372
21.46	0.34	0.35	0.36	0.350
22.73	0.32	0.325	0.34	0.328
24.0	0.29	0.30	0.32	0.303
25.27	0.26 (0.29)	0.275	0.29	0.275
Bottom 26.54	0.03 (0.065) —	— 0.03 (0.065) ——→	0.03 ——	—→ 0.03. Rext.
~~27.81~~				
~~29.08~~				

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 9/87

SLAG SAMPLE: 0.95 Fe/SiO_2

Atm.: H.P. Ar (gettered).

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.03 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.62	—
4.95	—	0.980	—
7.49	—	0.807	—
10.03	0.305	0.647	0.494
11.3	0.284	0.602	0.497
12.57	0.265	0.553	0.507
13.84	0.247	0.515	0.509
15.11	0.230	0.480	0.511
16.38	0.214	0.450	0.510
17.65	0.199	0.423	0.506
18.92	0.186	0.397	0.507
20.19	0.174	0.372	0.509
21.46	0.164	0.350	0.513
22.73	0.154	0.328	0.517
24.0	0.146	0.303	0.535
25.27	0.139	0.275	0.567
26.54	—	—	—
27.81	—	—	—
29.08	—	—	—

wide – 0.511 ± 0.009

narrow – 0.509 ± 0.002

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.95 Fe/SiO_2

DATE: DEC. 9/87

Additions made to sample:

100g as-received + 0.13g SiO_2

Atm.: H.P. Ar (gettered)

Total wt. of sample: 100.13g

Total wt. w/crucible: init.- 147.53g
finl.- 147.49g

RUN#: 1

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	112	0.0	2.4
1	73	4.95	0.96
1	53	7.49	0.75
1	33	10.03	0.62
1	23	11.3	0.565
1	13	12.57	0.535
1	03	13.84	0.495
1	993	15.11	0.465
1	983	16.38	0.44
1	973	17.65	0.41
1	963	18.92	0.39
1	953	20.19	0.365
1	943	21.46	0.35
1	933	22.73	0.33
1	923	24.0	0.31
1	913	25.27	0.285
1	BOTTOM ~~903~~	~~26.54~~	0.08
		27.81	
		29.08	
		Depth. 26.5 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 9/87

SLAG SAMPLE: 0.95 Fe/SiO_2

Atm.: HP. Ar.

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.08 Ω

RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	——	2.4	——
4.95	——	0.96	——
7.49	——	0.75	——
10.03	0.305	0.62	0.565
11.3	0.284	0.565	0.586
12.57	0.265	0.535	0.582
13.84	0.247	0.495	0.595
15.11	0.230	0.465	0.597
16.38	0.214	0.44	0.594
17.65	0.199	0.41	0.603
18.92	0.186	0.39	0.600
20.19	0.174	0.365	0.611
21.46	0.164	0.35	0.607
22.73	0.154	0.33	0.616
24.0	0.146	0.31	0.635
25.27	0.139	0.285	0.678
26.54	——	——	——
27.81	——	——	——
29.08	——	——	——

wide – 0.602 ± 0.015

narrow – 0.603 ± 0.007

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.95 Fe/SiO_2

DATE: DEC. 9/87

Additions made to sample:

100 g as-received ± 0.13 g SiO_2

Atm.: H.P. Ar (Gettered)

Total wt. of sample: 100.13 g

Total wt. w/crucible: init.- 147.53 g

finl.- 147.49 g

RUN#: 2

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	112	0.0	2.35
1	73	4.95	~~[illegible]~~ 0.94
1	53	7.49	0.73
1	33	10.03	0.60
1	23	11.3	0.555
1	13	12.57	0.51
1	03	13.84	0.46
1	993	15.11	0.43
1	983	16.38	0.40
1	973	17.65	0.38
1	963	18.92	0.36
1	953	20.19	0.335
1	943	21.46	0.315
1	933	22.73	0.30
1	923	24.0	0.28
1	913	25.27	0.25
1	BOTTOM ~~903~~	26.54	0.04
		27.81	
		29.08	
		Depth. 26.5 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 9/87

SLAG SAMPLE: 0.95 Fe/SiO_2

Atm.: H.P. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.04 Ω   RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.35	—
4.95	—	0.94	—
7.49	—	0.73	—
10.03	0.305	0.60	0.545
11.3	0.284	0.555	0.551
12.57	0.265	0.51	0.564
13.84	0.247	0.46	0.588
15.11	0.230	0.43	~~[illegible]~~ 0.590
16.38	0.214	0.40	0.594
17.65	0.199	0.38	0.585
18.92	0.186	0.36	0.581
20.19	0.174	0.335	0.590
21.46	0.164	0.315	0.596
22.73	0.154	0.30	0.592
24.0	0.146	0.28	0.608
25.27	0.139	0.25	0.662
26.54	—	—	—
27.81	—	—	—
29.08	—	—	—

wide - 0.585 ± 0.016

narrow - 0.589 ± 0.006

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.95 Fe/SiO_2

DATE: DEC. 9/87

Additions made to sample:

100 g as-received + 0.13 g SiO_2

Atm.: H.P. Ar (gettered)

Total wt. of sample: 100.13 g

Total wt. w/crucible: init.- 147.53 g

finl.- 147.49 g

RUN#: 3

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	112	0.0	2.35
1	73	4.95	0.94
1	53	7.49	0.725
1	33	10.03	0.585
1	23	11.3	0.54
1	13	12.57	0.495
1	03	13.84	0.46
1	993	15.11	0.43
1	983	16.38	0.40
1	973	17.65	0.37
1	963	18.92	0.35
1	953	20.19	0.325
1	943	21.46	0.31
1	933	22.73	0.295
1	923	24.0	0.275
1	913	25.27	0.25
1	BOTTOM.	26.54	0.04
		27.81	
		29.08	
		Depth 26.5 mm.	

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 9/87

SLAG SAMPLE: 0.95 Fe/SiO_2

Atm.: H.P. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.04 Ω

RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.35	———
4.95	———	0.94	———
7.49	———	0.725	———
10.03	0.305	0.585	0.560
11.3	0.284	0.54	0.568
12.57	0.265	0.495	0.582
13.84	0.247	0.46	0.588
15.11	0.230	0.43	0.590
16.38	0.214	0.40	0.594
17.65	0.199	0.37	0.603
18.92	0.186	0.35	0.600
20.19	0.174	0.325	0.611
21.46	0.164	0.31	0.607
22.73	0.154	0.295	0.604
24.0	0.146	0.275	0.621
25.27	0.139	0.25	0.662
26.54	———	———	———
27.81	———	———	———
29.08	———	———	———

wide - 0.597 ± 0.015

narrow - 0.603 ± 0.007

SLAG CONDUCTIVITY DETERMINATION

SUMMARY OF RESISTANCE MEASUREMENTS:

SLAG SAMPLE: 0.95 Fe/SiO_2

TEMPERATURE: 1300°C ± 5°

DATE: DEC. 9/87

Atm.: H.P. Ar (gettered).

DEPTH (mm)	RESISTANCE (ohms)			AVG. (2+3 only)
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.4	2.35	2.35	2.35
4.95	0.96	0.94	0.94	0.940
7.49	0.75	0.73	0.725	0.728
10.03	0.62	0.60	0.585	0.593
11.3	0.565	0.555	0.54	0.548
12.57	0.535	0.51	0.495	0.503
13.84	0.495	0.46	0.46	0.460
15.11	0.465	0.43	0.43	0.430
16.38	0.44	0.40	0.40	0.400
17.65	0.41	0.38	0.37	0.375
18.92	0.39	0.36	0.35	0.355
20.19	0.365	0.335	0.325	0.330
21.46	0.35	0.315	0.31	0.313
22.73	0.33	0.30	0.295	0.298
24.0	0.31	0.28	0.275	0.278
25.27	0.285	0.25	0.25	0.250
BOTTOM ~~26.54~~	0.08	0.04	0.04	0.04 R_{ext}.
27.81				
29.08				

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 9/87.

SLAG SAMPLE: 0.95 Fe/SiO_2

Atm.: A.P. Ar (gettered)

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.04 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (2+3)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	——	2.35	——
4.95	——	0.940	——
7.49	——	0.728	——
10.03	0.305	0.593	0.552
11.3	0.284	0.548	0.559
12.57	0.265	0.503	0.572
13.84	0.247	0.460	0.588
15.11	0.230	0.430	0.590
16.38	0.214	0.400	0.594
17.65	0.199	0.375	0.594
18.92	0.186	0.355	0.590
20.19	0.174	0.330	0.600
21.46	0.164	0.313	0.601
22.73	0.154	0.298	0.597
24.0	0.146	0.278	0.613
25.27	0.139	0.250	0.662
26.54	——	——	——
27.81	——	——	——
29.08	——	——	——

wide - 0.591 ± 0.015

narrow - 0.596 ± 0.005

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 9/87 X

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: HP. Ar.

SLAG SAMPLE: 0.95 Fe/SiO_2

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG. (1+3)
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.4	2.35	2.35	2.375
4.95	0.96	0.94	0.94	0.950
7.49	0.75	0.73	0.725	0.738
10.03	0.62	0.60	0.585	0.603
11.3	0.565	0.555	0.54	0.553
12.57	0.535	0.51	0.495	0.515
13.84	0.495	0.46	0.46	0.478
15.11	0.465	0.43	0.43	0.448
16.38	0.44	0.40	0.40	0.420
17.65	0.41	0.38	0.37	0.390
18.92	0.39	0.36	0.35	0.370
20.19	0.365	0.335	0.325	0.345
21.46	0.35	0.315	0.31	0.330
22.73	0.33	0.30	0.295	0.313
24.0	0.31	0.28	0.275	0.293
25.27	0.285	0.25	0.25	0.268
~~26.54~~	~~0.08~~	~~0.04~~	~~0.04~~	~~0.06~~ Rest.
27.81				
29.08				

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 9/87

SLAG SAMPLE: 0.95 Fe/SiO_2

Atm.: HP. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.06 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (1+3)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.375	—
4.95	—	0.950	—
7.49	—	0.738	—
10.03	0.305	0.603	0.562
11.3	0.284	0.553	0.576
12.57	0.265	0.515	0.582
13.84	0.247	0.478	0.591
15.11	0.230	0.448	0.593
16.38	0.214	0.420	0.594
17.65	0.199	0.390	0.603
18.92	0.186	0.370	0.600
20.19	0.174	0.345	0.610
21.46	0.164	0.330	0.607
22.73	0.154	0.313	0.609
24.0	0.146	0.293	0.627
25.27	0.139	0.268	0.668
26.54	—	—	—
27.81	—	—	—
29.08	—	—	—

wide - 0.599 ± 0.014

narrow - 0.603 ± 0.006.

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 9/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar.

SLAG SAMPLE: 0.95 Fe/SiO_2

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.4	2.35	2.35	2.37
4.95	0.96	0.94	0.94	0.947
7.49	0.75	0.73	0.725	0.735
10.03	0.62	0.60	0.585	0.602
11.3	0.565	0.555	0.54	0.553
12.57	0.535	0.51	0.495	0.513
13.84	0.495	0.46	0.46	0.472
15.11	0.465	0.43	0.43	0.442
16.38	0.44	0.40	0.40	0.413
17.65	0.41	0.38	0.37	0.387
18.92	0.39	0.36	0.35	0.367
20.19	0.365	0.335	0.325	0.342
21.46	0.35	0.315	0.31	0.325
22.73	0.33	0.30	0.295	0.308
24.0	0.31	0.28	0.275	0.288
25.27	0.285	0.25	0.25	0.262
BOTTOM. 26.54	0.08	0.04	0.04	0.053 Rect.
27.81				
29.08				

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 9/87

SLAG SAMPLE: 0.95 Fe/SiO_2

Atm.: H.P. Ar.

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.053 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.37	—
4.95	—	0.947	—
7.49	—	0.735	—
10.03	0.305	0.602	0.556
11.3	0.284	0.553	0.568
12.57	0.265	0.513	0.576
13.84	0.247	0.472	0.589
15.11	0.230	0.442	0.591
16.38	0.214	0.413	0.594
17.65	0.199	0.387	0.596
18.92	0.186	0.367	0.592
20.19	0.174	0.342	0.602
21.46	0.164	0.325	0.603
22.73	0.154	0.308	0.604
24.0	0.146	0.288	0.621
25.27	0.139	0.262	0.665
26.54	—	—	—
27.81	—	—	—
29.08	—	—	—

wide – 0.594 ± 0.014

narrow – 0.599 ± 0.005

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5wt.% Fe_2O_3

DATE: DEC. 11/87

Additions made to sample:

100g as-received + 0.13g SiO_2 + 5.0g Fe_2O_3

Atm.: H.P. Ar. (gettered.)

Total wt. of sample: 105.13g

Total wt. w/crucible: init.- 156.10g
finl.- 155.95g

RUN#: 1

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	95	0.0	1.9
1	56	4.95	0.86
1	36	7.49	0.665
1	16	10.03	0.545
1	06	11.3	0.50
1	996	12.57	0.46
1	986	13.84	0.435
1	976	15.11	0.40
1	966	16.38	0.375
1	956	17.65	0.345
1	946	18.92	0.32
1	936	20.19	0.30
1	926	21.46	0.275
1	916	22.73	0.255
1 (0.3)	906	24.0	0.23 (0.27)
1 (0.3)	896	25.27	0.20 (0.245)
1 (0.3)	886	26.54	0.165 (0.21)
1 (0.3)	876	27.81	0.08 (0.12)
1 (0.3)	872	~~29.08~~ BOTTOM	0.07 (0.115)
		Depth. 28.3 mm.	

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5wt.% Fe_2O_3

TEMPERATURE: 1250°C ± 5°

DATE: DEC. 11/87

Atm.: HP. Ar.

$r_{ext.}$ = 0.07 Ω

RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	1.9	—
4.95	—	0.86	—
7.49	—	0.665	—
10.03	0.305	0.545	0.642
11.3	0.284	0.50	0.660
12.57	0.265	0.46	0.679
13.84	0.247	0.435	0.677
15.11	0.230	0.40	0.697
16.38	0.214	0.375	0.702
17.65	0.199	0.345	0.724
18.92	0.186	0.32	0.744
20.19	0.174	0.30	0.757
21.46	0.164	0.275	0.800
22.73	0.154	0.255	0.832
24.0	0.146	0.23	0.913
25.27	0.139	0.20	1.069
26.54	—	0.165	—
27.81	—	0.08	—
29.08	—	—	—

wide – 0.744 ± 0.077

narrow – 0.709 ± 0.026

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5 wt.% Fe_2O_3 DATE: DEC. 11/87

Additions made to sample: Atm.: H.P. Ar (gettered)

100g as-received + 0.13g SiO_2 + 5.0g Fe_2O_3

Total wt. of sample: 105.13g Total wt. w/crucible: init.- 156.10g

finl.- 155.95g

RUN#: 2 TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	96	0.0	2.1
1	57	4.95	0.90
1	37	7.49	0.71
1	17	10.03	0.58
1	07	11.3	0.535
1	997	12.57	0.50
1	987	13.84	0.46
1	977	15.11	0.43
1	967	16.38	0.40
1	957	17.65	0.38
1	947	18.92	0.35
1	937	20.19	0.325
1	927	21.46	0.30
1	917	22.73	0.28
1	907	24.0	0.26
1	897	25.27	0.23
1	887	26.54	0.20
1	877	27.81	0.10
1	BOTTOM 874	29.08	0.08
		Depth. 28.2 mm.	

CONDUCTIVITY CALCULATION:

DATE: DEC. 11/87

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5% Fe_2O_3

Atm.: HP. Ar

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.08 Ω

RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.1	———
4.95	———	0.90	———
7.49	———	0.71	———
10.03	0.305	0.58	0.610
11.3	0.284	0.535	0.624
12.57	0.265	0.50	0.631
13.84	0.247	0.46	0.650
15.11	0.230	0.43	0.657
16.38	0.214	0.40	0.669
17.65	0.199	0.38	0.663
18.92	0.186	0.35	~~0.688~~ 0.689
20.19	0.174	0.325	0.710
21.46	0.164	0.30	0.745
22.73	0.154	0.28	0.770
24.0	0.146	0.26	0.811
25.27	0.139	0.23	0.927
26.54	———	0.20	———
27.81	———	0.10	———
29.08	———	———	———

wide - 0.693 ± 0.060

narrow - 0.666 ± 0.015

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5 wt.% Fe_2O_3

DATE: DEC. 11/87

Additions made to sample:

100g as-received + 0.13g SiO_2 + 5.0g Fe_2O_3

Atm.: H.P. Ar (gettered)

Total wt. of sample: 105.13g

Total wt. w/crucible: init.- 156.10g
finl.- 155.95g

RUN#: 3

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	96	0.0	2.07
1	57	4.95	0.895
1	37	7.49	0.70
1	17	10.03	0.585
1	07	11.3	0.54
1	997	12.57	0.50
1	987	13.84	0.46
1	977	15.11	0.435
1	967	16.38	0.40
1	957	17.65	0.375
1	947	18.92	0.345
1	937	20.19	0.325
1	927	21.46	0.30
1	917	22.73	0.28
1	907	24.0	0.26
1	897	25.27	0.225
1	887	26.54	0.19
1	877	27.81	0.10
1	874	BOTTOM ~~29.00~~	0.08
		Depth. 28.2 mm.	

CONDUCTIVITY CALCULATION:

DATE: DEC. 11/87

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5% Fe_2O_3

Atm.: HP. Ar

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.08 Ω

RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.07	———
4.95	———	0.895	———
7.49	———	0.70	———
10.03	0.305	0.585	0.604
11.3	0.284	0.54	0.617
12.57	0.265	0.50	0.631
13.84	0.247	0.46	0.650
15.11	0.230	0.435	0.648
16.38	0.214	0.40	0.669
17.65	0.199	0.375	0.675
18.92	0.186	0.345	0.702
20.19	0.174	0.325	0.710
21.46	0.164	0.30	0.745
22.73	0.154	0.28	0.770
24.0	0.146	0.26	0.811
25.27	0.139	0.225	0.959
26.54	———	0.19	———
27.81	———	0.10	———
29.08	———	———	———

wide – 0.693 ± 0.061

narrow – 0.669 ± 0.022

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 11/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar (gettered)

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5wt.% Fe_2O_3

TEMPERATURE: 1250°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG. (2+3 only).
	RUN# 1	RUN# 2	RUN# 3	
0.0	1.9	2.1	2.07	2.085
4.95	0.86	0.90	0.895	0.898
7.49	0.665	0.71	0.70	0.705
10.03	0.545	0.58	0.585	0.583
11.3	0.50	0.535	0.54	0.538
12.57	0.46	0.50	0.50	0.500
13.84	0.435	0.46	0.46	0.460
15.11	0.40	0.43	0.435	0.433
16.38	0.375	0.40	0.40	0.400
17.65	0.345	0.38	0.375	0.378
18.92	0.32	0.35	0.345	0.348
20.19	0.30	0.325	0.325	0.325
21.46	0.275	0.30	0.30	0.300
22.73	0.255	0.28	0.28	0.280
24.0	0.23	0.26	0.26	0.260
25.27	0.20	0.23	0.225	0.228
26.54	0.165	0.20	0.19	0.195
27.81	0.08	0.10	0.10	0.100
29.08		[illegible]		
BOTTOM.	Rext. 0.07.	Rext. 0.08	Rext. 0.08	Rext = 0.08.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 11/87

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5wt.% Fe_2O_3

Atm.: H.P. Ar (gettered)

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.08 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (2+3)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.085	—
4.95	—	0.898	—
7.49	—	0.705	—
10.03	0.305	0.583	0.606
11.3	0.284	0.538	0.620
12.57	0.265	0.500	0.631
13.84	0.247	0.460	0.650
15.11	0.230	0.433	0.652
16.38	0.214	0.400	0.669
17.65	0.199	0.378	0.668
18.92	0.186	0.348	0.694
20.19	0.174	0.325	0.710
21.46	0.164	0.300	0.745
22.73	0.154	0.280	0.770
24.0	0.146	0.260	0.811
25.27	0.139	0.228	0.939
26.54	—	0.195	—
27.81	—	0.100	—
29.08	—	—	—

wide - 0.693 ± 0.061

narrow - 0.667 ± 0.018

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 11/87
Atm.: HP. Ar

SUMMARY OF RESISTANCE MEASUREMENTS:

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5% Fe_2O_3

TEMPERATURE: 1250°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	1.9	2.1	2.07	2.023
4.95	0.86	0.90	0.895	0.885
7.49	0.665	0.71	0.70	0.692
10.03	0.545	0.58	0.585	0.570
11.3	0.50	0.535	0.54	0.525
12.57	0.46	0.50	0.50	0.487
13.84	0.435	0.46	0.46	0.452
15.11	0.40	0.43	0.435	0.422
16.38	0.375	0.40	0.40	0.392
17.65	0.345	0.38	0.375	0.367
18.92	0.32	0.35	0.345	0.338
20.19	0.30	0.325	0.325	0.317
21.46	0.275	0.30	0.30	0.292
22.73	0.255	0.28	0.28	0.272
24.0	0.23	0.26	0.26	0.25
25.27	0.20	0.23	0.225	0.218
26.54	0.165	0.20	0.19	0.185
27.81	0.08	0.10	0.10	—
29.08				
BOTTOM.	Rext. 0.07	Rext. 0.08	Rext. 0.08.	0.077 Rext.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5% Fe_2O_3

TEMPERATURE: 1250°C ± 5°

DATE: DEC. 11/87

Atm.: HP. Ar

$r_{ext.}$ = 0.077 Ω

DEPTH (mm)	CELL CONSTANT (cm⁻¹)	RESISTANCE (ohm)	CONDUCTIVITY (ohm⁻¹.cm⁻¹)
0.0	—	2.023	—
4.95	—	0.885	—
7.49	—	0.692	—
10.03	0.305	0.570	0.619
11.3	0.284	0.525	0.634
12.57	0.265	0.487	0.646
13.84	0.247	0.452	0.659
15.11	0.230	0.422	0.667
16.38	0.214	0.392	0.679
17.65	0.199	0.367	0.686
18.92	0.186	0.338	0.713
20.19	0.174	0.317	0.725
21.46	0.164	0.292	0.763
22.73	0.154	0.272	0.790
24.0	0.146	0.25	0.844
25.27	0.139	0.218	0.986.
26.54	—	0.185	—
27.81	—	—	—
29.08	—	—	—

wide - 0.709 ± 0.066

narrow - 0.681 ± 0.021

X

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5 wt.% Fe_2O_3

DATE: DEC. 11/87

Additions made to sample:

100g as-received + 0.13g SiO_2 + 5.0g Fe_2O_3

Atm.: H.P. Ar (Gettered)

Total wt. of sample: 105.13g

Total wt. w/crucible: init.- 156.10g
finl.- 155.95g

RUN#: 1

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	99	0.0	1.85
1	60	4.95	0.78
1	40	7.49	0.61
1	20	10.03	0.51
1	10	11.3	0.465
1	~~9~~ 0	12.57	0.44
1	990	13.84	0.40
1	980	15.11	0.39
1	970	16.38	0.36
1	960	17.65	0.34
1	950	18.92	0.315
1	940	20.19	0.295
1	930	21.46	0.27
1	920	22.73	0.25
1	910	24.0	0.23
1	900	25.27	0.21
1	890	26.54	0.18
1	880	27.81	0.10
1	876	BOTTOM ~~29.08~~	Rext. = 0.08
		Depth. 28.3 mm.	

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5wt.% Fe_2O_3

TEMPERATURE: 1300°C ± 5°

DATE: DEC. 11/87

Atm.: HP. Ar

$r_{ext.}$ = 0.08 Ω RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	1.85	—
4.95	—	0.78	—
7.49	—	0.61	—
10.03	0.305	0.51	0.709
11.3	0.284	0.465	0.738
12.57	0.265	0.44	0.736
13.84	0.247	0.40	0.772
15.11	0.230	0.39	0.742
16.38	0.214	0.36	0.764
17.65	0.199	0.34	0.765
18.92	0.186	0.315	0.791
20.19	0.174	0.295	0.809
21.46	0.164	0.27	0.863
22.73	0.154	0.25	0.906
24.0	0.146	0.23	0.973
25.27	0.139	0.21	1.069
26.54	—	0.18	—
27.81	—	0.10	—
29.08	—	—	—

wide - 0.805 ± 0.077

narrow - 0.827 ± 0.057

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5 wt.% Fe_2O_3

DATE: DEC. 11/87

Additions made to sample:

100 g as-received + 0.13 g SiO_2 + 5.0 g Fe_2O_3

Atm.: H.P. Ar (gettered)

Total wt. of sample: 105.13 g

Total wt. w/crucible: init. - 156.10 g
finl. - 155.95 g

RUN#: 2

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	99	0.0	2.0
1	60	4.95	0.795
1	40	7.49	0.63
1	20	10.03	0.53
1	10	11.3	0.485
1	0	12.57	0.455
1	990	13.84	0.42
1	980	15.11	0.39
1	970	16.38	0.365
1	960	17.65	0.345
1	950	18.92	0.32
1	940	20.19	0.30
1	930	21.46	0.28
1	920	22.73	0.265
1	910	24.0	0.25
1	900	25.27	0.225
1	890	26.54	0.20
1	880	27.81	0.11
1	876	BOTTOM ~~29.08~~	Rext = 0.08
		Depth 28.3 mm.	

CONDUCTIVITY CALCULATION:

DATE: DEC. 11/87

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5 wt.% Fe_2O_3

Atm.: HP. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.08 Ω

RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.0	———
4.95	———	0.795	———
7.49	———	0.63	———
10.03	0.305	0.53	0.678
11.3	0.284	0.485	0.701
12.57	0.265	0.455	0.707
13.84	0.247	0.42	0.726
15.11	0.230	0.39	0.742
16.38	0.214	0.365	0.751
17.65	0.199	0.345	0.751
18.92	0.186	0.32	0.775
20.19	0.174	0.30	0.791
21.46	0.164	0.28	0.820
22.73	0.154	0.265	0.832
24.0	0.146	0.25	0.859
25.27	0.139	0.225	0.959.
26.54	———	0.20	———
27.81	———	0.11	———
29.08	———	———	———

wide - 0.769 ± 0.052

narrow - 0.794 ± 0.033

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5 wt.% Fe_2O_3

DATE: DEC. 11/87

Additions made to sample:

100 g as-received + 0.13 g SiO_2 + 5.0 g Fe_2O_3

Atm.: H.P. Ar (gettered)

Total wt. of sample: 105.13 g

Total wt. w/crucible: init. - 156.10 g

finl. - 155.95 g

RUN#: 3

TEMPERATURE: 1300 °C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	99	0.0	1.94
1	60	4.95	0.79
1	40	7.49	0.63
1	20	10.03	0.52
1	10	11.3	0.48
1	0	12.57	0.445
1	990	13.84	0.415
1	980	15.11	0.39
1	970	16.38	0.36
1	960	17.65	0.34
1	950	18.92	0.315
1	940	20.19	0.29
1	930	21.46	0.27
1	920	22.73	0.25
1	910	24.0	0.23
1	900	25.27	0.21
1	890	26.54	0.185
1	880	27.81	0.10
1	876	BOTTOM: ~~29.08~~	0.08
		Depth. 28.3 mm.	

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5% Fe_2O_3

TEMPERATURE: 1300°C ± 5°

DATE: DEC. 11/87

Atm.: H.P. Ar

$r_{ext.}$ = 0.08 Ω

RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	1.94	—
4.95	—	0.79	—
7.49	—	0.63	—
10.03	0.305	0.52	0.693
11.3	0.284	0.48	0.710
12.57	0.265	0.445	0.726
13.84	0.247	0.415	0.737
15.11	0.230	0.39	0.742
16.38	0.214	0.36	0.764
17.65	0.199	0.34	0.765
18.92	0.186	0.315	0.791
20.19	0.174	0.29	0.829
21.46	0.164	0.27	0.863
22.73	0.154	0.25	0.906
24.0	0.146	0.23	0.973
25.27	0.139	0.21	1.069
26.54	—	0.185	—
27.81	—	0.10	—
29.08	—	—	—

wide - 0.801 ± 0.083

narrow - 0.831 ± 0.056

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 11/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: HP. Ar.

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5wt.% Fe_2O_3

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG. (#1+3)
	RUN# 1	RUN# 2	RUN# 3	
0.0	1.85	2.0	1.94	1.895
4.95	0.78	0.795	0.79	0.785
7.49	0.61	0.63	0.63	0.620
10.03	0.51	0.53	0.52	0.515
11.3	0.465	0.485	0.48	0.473
12.57	0.44	0.455	0.445	0.443
13.84	0.40	0.42	0.415	0.408
15.11	0.39	0.39	0.39	0.390
16.38	0.36	0.365	0.36	0.360
17.65	0.34	0.345	0.34	0.340
18.92	0.315	0.32	0.315	0.315
20.19	0.295	0.30	0.29	0.293
21.46	0.27	0.28	0.27	0.270
22.73	0.25	0.265	0.25	0.250
24.0	0.23	0.25	0.23	0.230
25.27	0.21	0.225	0.21	0.210
26.54	0.18	0.20	0.185	0.183
27.81	0.10	0.11	0.10	0.100
~~29.08~~				
	Rest. 0.08 —	Rest 0.08 —	Rest. 0.08 —	0.08 Rest.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 11/87

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5wt.% Fe_2O_3

Atm.: HP. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.08 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (1+3)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	1.895	—
4.95	—	0.785	—
7.49	—	0.620	—
10.03	0.305	0.515	0.701
11.3	0.284	0.473	0.723
12.57	0.265	0.443	0.730
13.84	0.247	0.408	0.753
15.11	0.230	0.390	0.742
16.38	0.214	0.360	0.764
17.65	0.199	0.340	0.765
18.92	0.186	0.315	0.791
20.19	0.174	0.293	0.817
21.46	0.164	0.270	0.863
22.73	0.154	0.250	0.906
24.0	0.146	0.230	0.973
25.27	0.139	0.210	1.069
26.54	—	0.183	—
27.81	—	0.100	—
29.08	—	—	—

wide - 0.802 ± 0.080.

narrow - 0.828 ± 0.056.

SLAG CONDUCTIVITY DETERMINATION

SUMMARY OF RESISTANCE MEASUREMENTS:

SLAG SAMPLE: 0.95 Fe/SiO$_2$ with 5wt.% Fe$_2$O$_3$

TEMPERATURE: 1300°C ± 5°

DATE: DEC. 11/87

Atm.: H.P. Ar (gettered)

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	1.85	2.0	1.94	1.93
4.95	0.78	0.795	0.79	0.788
7.49	0.61	0.63	0.63	0.623
10.03	0.51	0.53	0.52	0.520
11.3	0.465	0.485	0.48	0.477
12.57	0.44	0.455	0.445	0.447
13.84	0.40	0.42	0.415	0.412
15.11	0.39	0.39	0.39	0.390
16.38	0.36	0.365	0.36	0.362
17.65	0.34	0.345	0.34	0.342
18.92	0.315	0.32	0.315	0.317
20.19	0.295	0.30	0.29	0.295
21.46	0.27	0.28	0.27	0.273
22.73	0.25	0.265	0.25	0.255
24.0	0.23	0.25	0.23	0.237
25.27	0.21	0.225	0.21	0.215
26.54	0.18	0.20	0.185	0.188
27.81	0.10	0.11	0.10	0.103
~~29.08~~				
	Rext. 0.08	Rext. 0.08	Rext. 0.08	Rext. 0.08

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC.11/87

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5 wt.% Fe_2O_3

Atm.: H.P. Ar (gettered)

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.08 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	1.93	—
4.95	—	0.788	—
7.49	—	0.623	—
10.03	0.305	0.520	0.693
11.3	0.284	0.477	0.715
12.57	0.265	0.447	0.722
13.84	0.247	0.412	0.744
15.11	0.230	0.390	0.742
16.38	0.214	0.362	0.759
17.65	0.199	0.342	0.760
18.92	0.186	0.317	0.784
20.19	0.174	0.295	0.809
21.46	0.164	0.273	0.850
22.73	0.154	0.255	0.880
24.0	0.146	0.237	0.930
25.27	0.139	0.215	1.030
26.54	—	0.188	—
27.81	—	0.103	—
29.08	—	—	—

wide - 0.790 ± 0.069

narrow - 0.817 ± 0.049.

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 1.05 Fe/SiO_2

DATE: DEC. 17/87

Additions made to sample:

Atm.: H.P. Ar (gettered)

100g as-received + 2.69g Fe_2O_3 + 0.94g Fe powder

Total wt. of sample: 103.63g

Total wt. w/crucible: init.- 152.82g
finl.- 152.72g

RUN#: 1

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	98	0.0	2.8
3	59	4.95	1.05
1	39	7.49	0.84
1	19	10.03	0.685
1	09	11.3	0.625
1	999	12.57	0.575
1	989	13.84	0.535
1	979	15.11	0.50
1	969	16.38	0.465
1	959	17.65	0.435
1	949	18.92	0.405
1	939	20.19	0.38
1	929	21.46	0.35
1	919	22.73	0.325
1	909	24.0	0.30
1 (0.3)	899	25.27	0.27 (0.285)
1 (0.3)	889	26.54	0.215 (0.235)
1 (0.3)	880	BOTTOM. 27.81	0.06 (0.09)
		29.08	
		Depth 27.7 mm.	

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 1.05 Fe/SiO_2

TEMPERATURE: 1250°C ± 5°

DATE: DEC. 17/87

Atm.: HP. Ar

$r_{ext.}$ = 0.06 Ω

RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.8	—
4.95	—	1.05	—
7.49	—	0.84	—
10.03	0.305	0.685	0.488
11.3	0.284	0.625	0.503
12.57	0.265	0.575	0.515
13.84	0.247	0.535	0.520
15.11	0.230	0.50	0.523
16.38	0.214	0.465	0.528
17.65	0.199	0.435	0.531
18.92	0.186	0.405	0.539
20.19	0.174	0.38	0.544
21.46	0.164	0.35	0.566
22.73	0.154	0.325	0.581
24.0	0.146	0.30	0.608
25.27	0.139	0.27	0.662
26.54	—	0.215	—
27.81	—	—	—
29.08	—	—	—

wide - 0.542 ± 0.031

narrow - 0.552 ± 0.021

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 1.05 Fe/SiO_2

DATE: DEC. 17/87

Additions made to sample:

100g as-received + 2.69g Fe_2O_3 + 0.94g Fe powder

Atm.: H.P. Ar (gettered).

Total wt. of sample: 103.63g

Total wt. w/crucible: init.- 152.82g
finl.- 152.72g

RUN#: 2

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	99	0.0	2.7
3	60	4.95	1.0
1	40	7.49	0.835
1	20	10.03	0.695
1	10	11.3	0.64
1	0	12.57	0.58
1	990	13.84	0.54
1	980	15.11	0.505
1	970	16.38	0.47
1	960	17.65	0.44
1	950	18.92	0.41
1	940	20.19	0.385
1	930	21.46	0.36
1	920	22.73	0.33
1	910	24.0	0.30
1 (0.3)	900	25.27	0.28 (0.3)
1(0.3)	890	26.54	0.225 (0.24)
1(0.3)	882	BOTTOM. ~~27.81~~	0.06 (0.09)
		29.08	
		Depth. 27.6 mm.	

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 1.05 Fe/SiO_2

TEMPERATURE: 1250°C ± 5°

DATE: DEC. 17/87

Atm.: HP. Ar

$r_{ext.}$ = 0.06 Ω

RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.7	—
4.95	—	1.0	—
7.49	—	0.835	—
10.03	0.305	0.695	0.480
11.3	0.284	0.64	0.490
12.57	0.265	0.58	0.510
13.84	0.247	0.54	0.515
15.11	0.230	0.505	0.517
16.38	0.214	0.47	0.522
17.65	0.199	0.44	0.524
18.92	0.186	0.41	0.531
20.19	0.174	0.385	0.535
21.46	0.164	0.36	0.547
22.73	0.154	0.33	0.570
24.0	0.146	0.30	0.608
25.27	0.139	0.28	0.632
26.54	—	0.225	—
27.81	—	—	—
29.08	—	—	—

wide – 0.534 ± 0.032

narrow – 0.541 ± 0.018

SLAG CONDUCTIVITY DETERMINATION

X

SLAG SAMPLE: 1.05 Fe/SiO_2

DATE: DEC. 17/87

Additions made to sample:

100 g as-received + 2.69 g Fe_2O_3 + 0.94 g Fe powder

Atm.: H.P. Ar (gettered)

Total wt. of sample: 103.63 g

Total wt. w/crucible: **init.**- 152.82 g
finl.- 152.72 g

RUN#: 3

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	99	0.0	2.8
3	60	4.95	1.05
1	40	7.49	0.85
1	20	10.03	0.71
1	10	11.3	0.65
1	0	12.57	0.60
1	990	13.84	0.56
1	980	15.11	0.525
1	970	16.38	0.49
1	960	17.65	0.46
1	950	18.92	0.43
1	940	20.19	0.40
1	930	21.46	0.375
1	920	22.73	0.35
1	910	24.0	0.32
1 (0.3)	900	25.27	0.285 (0.295)
1 (0.3)	890	26.54	0.23 (0.245)
1 (0.3)	882	BOTTOM. 27.81	0.06 (0.09)
		~~29.08~~	
		Depth. 27.6 mm.	

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 1.05 Fe/SiO_2

TEMPERATURE: 1250°C ± 5°

DATE: DEC. 17/87

Atm.: HP. Ar

$r_{ext.}$ = 0.06Ω

RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1} . cm^{-1}$)
0.0	—	2.8	—
4.95	—	1.05	—
7.49	—	0.85	—
10.03	0.305	0.71	0.469
11.3	0.284	0.65	0.481
12.57	0.265	0.60	0.491
13.84	0.247	0.56	0.494
15.11	0.230	0.525	0.495
16.38	0.214	0.49	0.498
17.65	0.199	0.46	0.498
18.92	0.186	0.43	0.503
20.19	0.174	0.40	0.512
21.46	0.164	0.375	0.520
22.73	0.154	0.35	0.531
24.0	0.146	0.32	0.561
25.27	0.139	0.285	0.618
26.54	—	0.23	—
27.81	—	—	—
29.08	—	—	—

wide – 0.508 ± 0.023

narrow – 0.513 ± 0.013

SLAG CONDUCTIVITY DETERMINATION

SUMMARY OF RESISTANCE MEASUREMENTS:

SLAG SAMPLE: 1.05 Fe/SiO_2

TEMPERATURE: 1250°C ± 5°

DATE: DEC. 17/87

Atm.: HP. Ar

DEPTH (mm)	RESISTANCE (ohms)			AVG. (1+2)
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.8	2.7	2.8	2.750
4.95	1.05	1.0	1.05	1.025
7.49	0.84	0.835	0.85	0.838
10.03	0.685	0.695	0.71	0.690
11.3	0.625	0.64	0.65	0.633
12.57	0.575	0.58	0.60	0.578
13.84	0.535	0.54	0.56	0.538
15.11	0.50	0.505	0.525	0.503
16.38	0.465	0.47	0.49	0.468
17.65	0.435	0.44	0.46	0.438
18.92	0.405	0.41	0.43	0.408
20.19	0.38	0.385	0.40	0.383
21.46	0.35	0.36	0.375	0.355
22.73	0.325	0.33	0.35	0.328
24.0	0.30	0.30	0.32	0.300
25.27	0.27	0.28	0.285	0.275
26.54	0.215	0.225	0.23	0.220
~~27.81~~				
~~29.08~~	Rext 0.06 —	Rext 0.06 —	Rext 0.06 —	0.06 Rext.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 17/87

SLAG SAMPLE: 1.05 Fe/SiO_2

Atm.: HP. Ar

TEMPERATURE: ~~1300°C ± 5~~ 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (1+2)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.750	—
4.95	—	1.025	—
7.49	—	0.838	—
10.03	0.305	0.690	0.484
11.3	0.284	0.633	0.496
12.57	0.265	0.578	0.512
13.84	0.247	0.538	0.517
15.11	0.230	0.503	0.519
16.38	0.214	0.468	0.525
17.65	0.199	0.438	0.526
18.92	0.186	0.408	0.534
20.19	0.174	0.383	0.539
21.46	0.164	0.355	0.556
22.73	0.154	0.328	0.575
24.0	0.146	0.300	0.608
25.27	0.139	0.275	0.647
26.54	—	0.220	—
27.81	—	—	—
29.08	—	—	—

wide – 0.537 ± 0.032

narrow – 0.546 ± 0.020

SLAG CONDUCTIVITY DETERMINATION

SUMMARY OF RESISTANCE MEASUREMENTS:

SLAG SAMPLE: 1.05 Fe/SiO$_2$

TEMPERATURE: 1250°C ± 5°

DATE: DEC. 17/87

Atm.: H.P. Ar (gettered)

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.8	2.7	2.8	2.77
4.95	1.05	1.0	1.05	1.03
7.49	0.84	0.835	0.85	0.842
10.03	0.685	0.695	0.71	0.697
11.3	0.625	0.64	0.65	0.638
12.57	0.575	0.58	0.60	0.585
13.84	0.535	0.54	0.56	0.545
15.11	0.50	0.505	0.525	0.510
16.38	0.465	0.47	0.49	0.475
17.65	0.435	0.44	0.46	0.445
18.92	0.405	0.41	0.43	0.415
20.19	0.38	0.385	0.40	0.388
21.46	0.35	0.36	0.375	0.362
22.73	0.325	0.33	0.35	0.335
24.0	0.30	0.30	0.32	0.307
25.27	0.27	0.28	0.285	0.278
26.54	0.215	0.225	0.23	0.223
~~27.81~~				
~~29.08~~	Rext. 0.06	Rext. 0.06	Rext. 0.06	Rext 0.06.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 17/87

SLAG SAMPLE: 1.05 Fe/SiO_2

Atm.: H.P. Ar (gettered)

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.77	—
4.95	—	1.03	—
7.49	—	0.842	—
10.03	0.305	0.697	0.479
11.3	0.284	0.638	0.491
12.57	0.265	0.585	0.505
13.84	0.247	0.545	0.509
15.11	0.230	0.510	0.511
16.38	0.214	0.475	0.516
17.65	0.199	0.445	0.517
18.92	0.186	0.415	0.524
20.19	0.174	0.388	0.530
21.46	0.164	0.362	0.543
22.73	0.154	0.335	0.560
24.0	0.146	0.307	0.591
25.27	0.139	0.278	0.638
26.54	—	0.223	—
27.81	—	—	—
29.08	—	—	—

wide - 0.527 ± 0.028

narrow - 0.535 ± 0.017

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 1.05 Fe/SiO_2

DATE: DEC. 17/87

Additions made to sample:

100 g as-received + 2.69 g Fe_2O_3 + 0.94 g Fe powder

Atm.: H.P. Ar (gettered)

Total wt. of sample: 103.63g

Total wt. w/crucible: init.- 152.82g

finl.- 152.72g

RUN#: 1

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	98	0.0	2.2
1	59	4.95	0.92
1	39	7.49	0.72
1	19	10.03	0.695
1	09	11.3	0.55
1	999	12.57	0.51
1	989	13.84	0.48
1	979	15.11	0.445
1	969	16.38	0.42
1	959	17.65	0.395
1	949	18.92	0.37
1	939	20.19	0.35
1	929	21.46	0.33
1	919	22.73	0.305
1	909	24.0	0.30
1 (0.3)	899	25.27	0.26 (0.270)
1 (0.3)	889	26.54	0.16 (0.175)
1 (0.3)	883	BOTTOM. ~~27.81~~	0.12 (0.14)
		29.08	
		Depth. 27.3mm	

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 1.05 Fe/SiO_2

TEMPERATURE: 1300 °C ± 5°

DATE: DEC. 17/87

Atm.: HP. Ar

$r_{ext.}$ = 0.12 Ω

RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.2	—
4.95	—	0.92	—
7.49	—	0.72	—
10.03	0.305	0.695	0.575
11.3	0.284	0.55	0.660
12.57	0.265	0.51	0.679
13.84	0.247	0.48	0.686
15.11	0.230	0.445	0.708
16.38	0.214	0.42	0.713
17.65	0.199	0.395	0.724
18.92	0.186	0.37	0.744
20.19	0.174	0.35	0.757
21.46	0.164	0.33	0.781
22.73	0.154	0.305	0.832
24.0	0.146	0.30	0.811
25.27	0.139	0.26	0.993
26.54	—	0.16	—
27.81	—	—	—
29.08	—	—	—

wide – 0.736 ± 0.055

narrow – 0.715 ± 0.021

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 1.05 Fe/SiO_2

DATE: DEC. 17/87

Additions made to sample:

100g as-received + 2.69g Fe_2O_3 + 0.94 Fe powder

Atm.: H.P. Ar (gettered)

Total wt. of sample: 103.63g

Total wt. w/crucible: init.- 152.82g

finl.- 152.72g

RUN#: 2

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	100	0.0	2.4
1	61	4.95	0.94
1	41	7.49	0.74
1	21	10.03	0.62
1	11	11.3	0.57
1	01	12.57	0.52
1	991	13.84	0.49
1	981	15.11	0.45
1	971	16.38	0.42
1	961	17.65	0.395
1	951	18.92	0.37
1	941	20.19	0.35
1	931	21.46	0.325
1	921	22.73	0.30
1 (0.3)	911	24.0	0.28 (0.285)
1 (0.3)	901	25.27	0.25 (0.255)
1 (0.3)	891	26.54	0.20 (0.215)
1 (0.3)	882 BOTTOM.	~~27.81~~	0.12 (0.145)
		29.08	
		Depth. 27.7 mm.	

CONDUCTIVITY CALCULATION:

DATE: DEC. 17/87

SLAG SAMPLE: 1.05 Fe/SiO_2

Atm.: HP. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.12 Ω RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.4	—
4.95	—	0.94	—
7.49	—	0.74	—
10.03	0.305	0.62	0.610
11.3	0.284	0.57	0.631
12.57	0.265	0.52	0.663
13.84	0.247	0.49	0.668
15.11	0.230	0.45	0.697
16.38	0.214	0.42	0.713
17.65	0.199	0.395	0.724
18.92	0.186	0.37	0.744
20.19	0.174	0.35	0.757
21.46	0.164	0.325	0.800
22.73	0.154	0.30	0.856
24.0	0.146	0.28	0.913
25.27	0.139	0.25	1.069
26.54	—	0.20	—
27.81	—	—	—
29.08	—	—	—

wide - 0.742 ± 0.085

narrow - 0.709 ± 0.029.

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 1.05 Fe/SiO_2

DATE: DEC. 17/87

Additions made to sample:

100g as-received + 2.69g Fe_2O_3 + 0.94g Fe powder.

Atm.: H.P. Ar (gettered)

Total wt. of sample: 103.63g

Total wt. w/crucible: init.- 152.82g
finl.- 152.72g

RUN#: 3

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	100	0.0	2.4
1	61	4.95	0.95
1	41	7.49	0.74
1	21	10.03	0.61
1	11	11.3	0.56
1	01	12.57	0.52
1	991	13.84	0.48
1	981	15.11	0.44
1	971	16.38	0.42
1	961	17.65	0.39
1	951	18.92	0.365
1	941	20.19	0.34
1	931	21.46	0.32
1	921	22.73	0.29
1 (0.3)	911	24.0	0.27 (0.285)
1 (0.3)	901	25.27	0.24 (0.26)
1 (0.3)	891	26.54	0.20 (0.22)
1 (0.3)	882 BOTTOM.	~~27.81~~	0.12 (0.14)
		29.08	
		Depth. 27.7 mm.	

CONDUCTIVITY CALCULATION:

DATE: DEC. 17/87

SLAG SAMPLE: 1.05 Fe/SiO_2

Atm.: H.P. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.12 Ω

RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.4	—
4.95	—	0.95	—
7.49	—	0.74	—
10.03	0.305	0.61	0.622
11.3	0.284	0.56	0.645
12.57	0.265	0.52	0.663
13.84	0.247	0.48	0.686
15.11	0.230	0.44	0.719
16.38	0.214	0.42	0.713
17.65	0.199	0.39	0.737
18.92	0.186	0.365	0.759
20.19	0.174	0.34	0.791
21.46	0.164	0.32	0.820
22.73	0.154	0.29	0.906
24.0	0.146	0.27	0.973
25.27	0.139	0.24	1.158
26.54	—	0.20	—
27.81	—	—	—
29.08	—	—	—

wide - 0.765 ± 0.102

narrow - 0.723 ± 0.027

SLAG CONDUCTIVITY DETERMINATION

SUMMARY OF RESISTANCE MEASUREMENTS:

SLAG SAMPLE: 1.05 Fe/SiO_2

TEMPERATURE: 1300°C ± 5°

DATE: DEC. 17/87

Atm.: HP. Ar.

DEPTH (mm)	RESISTANCE (ohms)			AVG. (#2+3).
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.2	2.4	2.4	2.40.
4.95	0.92	0.94	0.95	0.945
7.49	0.72	0.74	0.74	0.740
10.03	0.695	0.62	0.61	0.615
11.3	0.55	0.57	0.56	0.565
12.57	0.51	0.52	0.52	0.520
13.84	0.48	0.49	0.48	0.485
15.11	0.445	0.45	0.44	0.445
16.38	0.42	0.42	0.42	0.420
17.65	0.395	0.395	0.39	0.393
18.92	0.37	0.37	0.365	0.368
20.19	0.35	0.35	0.34	0.345
21.46	0.33	0.325	0.32	0.323
22.73	0.305	0.30	0.29	0.295
24.0	0.30	0.28	0.27	0.275
25.27	0.26	0.25	0.24	0.245
26.54	0.16	0.20	0.20	0.200
27.81				
~~29.08~~	R_{ext}. 0.12 —	R_{ext} 0.12 —	R_{ext}. 0.12 —	R_{ext}. 0.12

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 1.05 Fe/SiO_2

TEMPERATURE: 1300°C ± 5°

DATE: DEC. 17/87

Atm.: HP Ar

$r_{ext.}$ = 0.12 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (*2+3)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.40	—
4.95	—	0.945	—
7.49	—	0.740	—
10.03	0.305	0.615	0.616
11.3	0.284	0.565	0.638
12.57	0.265	0.520	0.663
13.84	0.247	0.485	0.677
15.11	0.230	0.445	0.708
16.38	0.214	0.420	0.713
17.65	0.199	0.393	0.729
18.92	0.186	0.368	0.750
20.19	0.174	0.345	0.773
21.46	0.164	0.323	0.808
22.73	0.154	0.295	0.880
24.0	0.146	0.275	0.942
25.27	0.139	0.245	1.112
26.54	—	0.200	—
27.81	—	—	—
29.08	—	—	—

wide – 0.753 ± 0.093

narrow – 0.715 ± 0.027

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 17/87

X

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: HP. Ar

SLAG SAMPLE: 1.05 Fe/SiO_2

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG. (#1+2)
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.2	2.4	2.4	2.30
4.95	0.92	0.94	0.95	~~1~~ 0.930
7.49	0.72	0.74	0.74	0.730
10.03	~~0.695~~	0.62	0.61	0.620
11.3	0.55	0.57	0.56	0.560
12.57	0.51	0.52	0.52	0.515
13.84	0.48	0.49	0.48	0.485
15.11	0.445	0.45	0.44	0.448
16.38	0.42	0.42	0.42	0.420
17.65	0.395	0.395	0.39	0.395
18.92	0.37	0.37	0.365	0.370
20.19	0.35	0.35	0.34	0.350
21.46	0.33	0.325	0.32	0.328
22.73	0.305	0.30	0.29	0.303
24.0	0.30	0.28	0.27	0.290
25.27	0.26	0.25	0.24	0.255
26.54	~~0.16~~	0.20	0.20	0.200
~~27.81~~				
~~29.08~~	Rext. 0.12 —	Rext. 0.12 —	Rext 0.12 —	0.12 Rext.

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 17/87

SLAG SAMPLE: 1.05 Fe/SiO_2

Atm.: HP. Ar.

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.12 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (1+2)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	———	2.30	———
4.95	———	0.930	———
7.49	———	0.730	———
10.03	0.305	0.620	0.610
11.3	0.284	0.560	0.645
12.57	0.265	0.515	0.671
13.84	0.247	0.485	0.677
15.11	0.230	0.448	0.701
16.38	0.214	0.420	0.713
17.65	0.199	0.395	0.724
18.92	0.186	0.370	0.744
20.19	0.174	0.350	0.757
21.46	0.164	0.328	0.788
22.73	0.154	0.303	0.842
24.0	0.146	0.290	0.859
25.27	0.139	0.255	1.030
26.54	———	0.200	———
27.81	———	———	———
29.08	———	———	———

wide - 0.738 ± 0.069

narrow - 0.712 ± 0.025

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 17/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar (gettered)

SLAG SAMPLE: 1.05 Fe/SiO_2

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	2.2	2.4	2.4	2.33
4.95	0.92	0.94	0.95	0.937
7.49	0.72	0.74	0.74	0.733
10.03	~~0.695~~	0.62	0.61	0.615
11.3	0.55	0.57	0.56	0.560
12.57	0.51	0.52	0.52	0.517
13.84	0.48	0.49	0.48	0.483
15.11	0.445	0.45	0.44	0.445
16.38	0.42	0.42	0.42	0.420
17.65	0.395	0.395	0.39	0.393
18.92	0.37	0.37	0.365	0.368
20.19	0.35	0.35	0.34	0.347
21.46	0.33	0.325	0.32	0.325
22.73	0.305	0.30	0.29	0.298
24.0	0.30	0.28	0.27	0.283
25.27	0.26	0.25	0.24	0.250
26.54	~~0.16~~	0.20	0.20	0.200
~~27.81~~				
~~29.08~~	Rext. 0.12	Rext. 0.12	Rext. 0.12	Rext. 0.12

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 17/87

SLAG SAMPLE: 1.05 Fe/SiO_2

Atm.: H.P. Ar (gettered).

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.12 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.33	—
4.95	—	0.937	—
7.49	—	0.733	—
10.03	0.305	0.615	0.616
11.3	0.284	0.560	0.645
12.57	0.265	0.517	0.668
13.84	0.247	0.483	0.680
15.11	0.230	0.445	0.708
16.38	0.214	0.420	0.713
17.65	0.199	0.393	0.729
18.92	0.186	0.368	0.750
20.19	0.174	0.347	0.767
21.46	0.164	0.325	0.800
22.73	0.154	0.298	0.865
24.0	0.146	0.283	0.896
25.27	0.139	0.250	1.070
26.54	—	0.200	—
27.81	—	—	—
29.08	—	—	—

wide — 0.747 ± 0.082

narrow — 0.716 ± 0.024

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5 wt.% Fe_2O_3

DATE: DEC. 19/87

Additions made to sample:

100g as-received + 7.87g Fe_2O_3 + 0.94g Fe powder.

Atm.: H.P. Ar (gettered)

Total wt. of sample: 108.81g

Total wt. w/crucible: init.- 157.85g
finl.- 157.67g

RUN#: 1

TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	121	0.0	1.75
1	82	4.95	0.76
1	62	7.49	0.61
1	42	10.03	0.52
1	32	11.3	0.48
1	22	12.57	0.44
1	12	13.84	0.41
1	02	15.11	0.38
1	992	16.38	0.355
1	982	17.65	0.33
1	972	18.92	0.31
1	962	20.19	0.29
1 (0.3)	952	21.46	0.265 (0.28)
1 (0.3)	942	22.73	0.25 (0.265)
1 (0.3)	932	24.0	0.23 (0.245)
1 (0.3)	922	25.27	0.205 (0.224)
1 (0.3)	912	26.54	0.18 (0.197)
1 (0.3)	902	27.81	0.08 (0.10)
1 (0.3)	899	BOTTOM ~~29.08~~	0.075 (0.091)
		Depth. 28.2 mm.	

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5% Fe_2O_3

TEMPERATURE: 1250 °C ± 5°

DATE: DEC. 19/87

Atm.: HP. Ar

$r_{ext.}$ = 0.075

RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	1.75	—
4.95	—	0.76	—
7.49	—	0.61	—
10.03	0.305	0.52	0.685
11.3	0.284	0.48	0.701
12.57	0.265	0.44	0.726
13.84	0.247	0.41	0.737
15.11	0.230	0.38	0.754
16.38	0.214	0.355	0.764
17.65	0.199	0.33	0.780
18.92	0.186	0.31	0.791
20.19	0.174	0.29	0.809
21.46	0.164	0.265	0.863
22.73	0.154	0.25	0.880
24.0	0.146	0.23	0.942
25.27	0.139	0.205	1.069.
26.54	—	0.18	—
27.81	—	0.08	—
29.08	—	—	—

wide – 0.795 ± 0.073

narrow – 0.765 ± 0.022

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5 wt.% Fe_2O_3 DATE: DEC. 19/87

Additions made to sample:

100 g as-received + 7.87 g Fe_2O_3 + 0.94 g Fe powder

Atm.: H.P. Ar (gettered)

Total wt. of sample: 108.81 g

Total wt. w/crucible: init. - 157.85 g
fini. - 157.67 g

RUN#: 2 TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	125	0.0	2.5
1	86	4.95	0.82
1	66	7.49	0.64
1	46	10.03	0.525
1	36	11.3	0.48
1	26	12.57	0.44
1	16	13.84	0.40
1	06	15.11	0.38
1	996	16.38	0.35
1	986	17.65	0.325
1	976	18.92	0.30
1	966	20.19	0.28
1 (0.3)	956	21.46	0.26 (0.290)
1 (0.3)	946	22.73	0.25 (0.272)
1 (0.3)	936	24.0	0.23 (0.252)
1 (0.3)	926	25.27	0.21 (0.233)
1 (0.3)	916	26.54	0.18 (0.21)
1 (0.3)	906	27.81	0.145 (0.17)
1 (0.3)	899	BOTTOM ~~29.08~~	0.06 (0.09)
		Depth. 28.9 mm.	

CONDUCTIVITY CALCULATION:

DATE: DEC. 19/87

SLAG SAMPLE: 1.05 Fe/SiO$_2$ with 5 wt.% Fe$_2$O$_3$

Atm.: HP. Ar.

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY (ohm^{-1}.cm^{-1})
0.0	———	2.5	———
4.95	———	0.82	———
7.49	———	0.64	———
10.03	0.305	0.525	0.656
11.3	0.284	0.48	0.676
12.57	0.265	0.44	0.697
13.84	0.247	0.40	0.726
15.11	0.230	0.38	0.719
16.38	0.214	0.35	0.738
17.65	0.199	0.325	0.751
18.92	0.186	0.30	0.775
20.19	0.174	0.28	0.791
21.46	0.164	0.26	0.820
22.73	0.154	0.25	0.811
24.0	0.146	0.23	0.859
25.27	0.139	0.21	0.927
26.54	———	0.18	———
27.81	———	0.145	———
29.08	———	———	———

wide – 0.760 ± 0.056

narrow – 0.742 ± 0.022

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5 wt.% Fe_2O_3 DATE: DEC. 19/87

Additions made to sample:

100g as-received + 7.87g Fe_2O_3 + 0.94g Fe powder Atm.: H.P. Ar (gettered)

Total wt. of sample: 108.81g Total wt. w/crucible: init.- 157.85g

finl.- 157.67g

RUN#: 3 TEMPERATURE: 1250°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	123	0.0	1.87
1	84	4.95	0.82
1	64	7.49	0.64
1	44	10.03	0.525
1	34	11.3	0.48
1	24	12.57	0.44
1	14	13.84	0.41
1	04	15.11	0.38
1	994	16.38	0.35
1	984	17.65	0.33
1	974	18.92	0.305
1	964	20.19	0.28
1 (0.3)	954	21.46	0.26 (0.29)
1 (0.3)	944	22.73	0.245 (0.27)
1 (0.3)	934	24.0	0.22 (0.25)
1 (0.3)	924	25.27	0.20 (0.23)
1 (0.3)	914	26.54	0.175 (0.205)
1 (0.3)	904	27.81	0.11 (0.14)
1 (0.3)	899	BOTTOM ~~29.08~~	0.06 (0.095)
		Depth. 28.4 mm.	

CONDUCTIVITY CALCULATION:

DATE: DEC. 19/87

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5 wt.% Fe_2O_3

Atm.: HP. Ar

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω

RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	1.87	—
4.95	—	0.82	—
7.49	—	0.64	—
10.03	0.305	0.525	0.656
11.3	0.284	0.48	0.676
12.57	0.265	0.44	0.697
13.84	0.247	0.41	0.706
15.11	0.230	0.38	0.719
16.38	0.214	0.35	0.738
17.65	0.199	0.33	0.737
18.92	0.186	0.305	0.759
20.19	0.174	0.28	0.791
21.46	0.164	0.26	0.820
22.73	0.154	0.245	0.832
24.0	0.146	0.22	0.913
25.27	0.139	0.20	0.993
26.54	—	0.175	—
27.81	—	0.11	—
29.08	—	—	—

wide – 0.763 ± 0.071

narrow – 0.732 ± 0.020

SLAG CONDUCTIVITY DETERMINATION

SUMMARY OF RESISTANCE MEASUREMENTS:

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5wt.% Fe_2O_3

TEMPERATURE: 1250°C ± 5°

DATE: DEC. 19/87

Atm.: HP. Ar

DEPTH (mm)	RESISTANCE (ohms)			AVG. (2+3).
	RUN# 1	RUN# 2	RUN# 3	
0.0	1.75	2.5	1.87	2.185
4.95	0.76	0.82	0.82	0.820
7.49	0.61	0.64	0.64	0.640
10.03	0.52	0.525	0.525	0.525
11.3	0.48	0.48	0.48	0.480
12.57	0.44	0.44	0.44	0.440
13.84	0.41	0.40	0.41	0.405
15.11	0.38	0.38	0.38	0.380
16.38	0.355	0.35	0.35	0.350
17.65	0.33	0.325	0.33	0.328
18.92	0.31	0.30	0.305	0.303
20.19	0.29	0.28	0.28	0.280
21.46	0.265	0.26	0.26	0.260
22.73	0.25	0.25	0.245	0.248
24.0	0.23	0.23	0.22	0.225
25.27	0.205	0.21	0.20	0.205
26.54	0.18	0.18	0.175	0.178
27.81	0.08	0.145	0.11	0.128
29.08	Rext. 0.075	Rext 0.06	Rext. 0.06 —	Rext 0.06

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 19/87

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5 wt% Fe_2O_3

Atm.: HP. Ar.

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (#2+3)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.185	—
4.95	—	0.820	—
7.49	—	0.640	—
10.03	0.305	0.525	0.656
11.3	0.284	0.480	0.676
12.57	0.265	0.440	0.697
13.84	0.247	0.405	0.716
15.11	0.230	0.380	0.719
16.38	0.214	0.350	0.738
17.65	0.199	0.328	0.743
18.92	0.186	0.303	0.765
20.19	0.174	0.280	0.791
21.46	0.164	0.260	0.820
22.73	0.154	0.248	0.819
24.0	0.146	0.225	0.885
25.27	0.139	0.205	0.959
26.54	—	0.178	—
27.81	—	0.128	—
29.08	—	—	—

wide - 0.761 ± 0.063

narrow - 0.736 ± 0.020

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 19/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar (gettered)

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5 wt.% Fe_2O_3

TEMPERATURE: 1250°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	1.75	2.5	1.87	2.04
4.95	0.76	0.82	0.82	0.80
7.49	0.61	0.64	0.64	0.63
10.03	0.52	0.525	0.525	0.523
11.3	0.48	0.48	0.48	0.480
12.57	0.44	0.44	0.44	0.440
13.84	0.41	0.40	0.41	0.407
15.11	0.38	0.38	0.38	0.380
16.38	0.355	0.35	0.35	0.352
17.65	0.33	0.325	0.33	0.328
18.92	0.31	0.30	0.305	0.305
20.19	0.29	0.28	0.28	0.283
21.46	0.265	0.26	0.26	0.262
22.73	0.25	0.25	0.245	0.248
24.0	0.23	0.23	0.22	0.227
25.27	0.205	0.21	0.20	0.205
26.54	0.18	0.18	0.175	0.178
27.81	0.08	0.145	0.11	—
29.08	Rext. 0.075	Rext. 0.06	Rext. 0.06	Rext. 0.06

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 19/87

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5 wt.% Fe_2O_3

Atm.: H.P. Ar (gettered)

TEMPERATURE: 1250°C ± 5°

$r_{ext.}$ = 0.06 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	2.04	—
4.95	—	0.80	—
7.49	—	0.63	—
10.03	0.305	0.523	0.659
11.3	0.284	0.480	0.676
12.57	0.265	0.440	0.697
13.84	0.247	0.407	0.712
15.11	0.230	0.380	0.719
16.38	0.214	0.352	0.733
17.65	0.199	0.328	0.743
18.92	0.186	0.305	0.759
20.19	0.174	0.283	0.780
21.46	0.164	0.262	0.812
22.73	0.154	0.248	0.819
24.0	0.146	0.227	0.874
25.27	0.139	0.205	0.959
26.54	—	0.178	—
27.81	—	—	—
29.08	—	—	—

wide – 0.757 ± 0.060

narrow – 0.733 ± 0.019

X

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5wt.% Fe_2O_3 DATE: DEC. 19/87

Additions made to sample: Atm.: H.P. Ar (gettered)

100g as-received + 7.87g Fe_2O_3 + 0.94 Fe powder

Total wt. of sample: 108.81g Total wt. w/crucible: init.- 157.85g

finl.- 157.67g

RUN#: 1 TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	127	0.0	1.8
1	88	4.95	0.73
1	68	7.49	0.57
1	48	10.03	0.465
1	38	11.3	0.43
1	28	12.57	0.405
1	18	13.84	0.38
1	08	15.11	0.35
1	998	16.38	0.33
1	988	17.65	0.30
1	978	18.92	0.28
1 (0.3)	968	20.19	0.265 (0.295)
1 (0.3)	958	21.46	0.25 (0.275)
1 (0.3)	948	22.73	0.23 (0.257)
1 (0.3)	938	24.0	0.21 (0.24)
1 (0.3)	928	25.27	0.195 (0.225)
1 (0.3)	918	26.54	0.175 (0.205)
1 (0.3)	908	27.81	0.140 (0.175)
1 (0.3)	899	BOTTOM ~~29.08~~	0.07 (0.10)
		Depth. 28.9 mm.	

CONDUCTIVITY CALCULATION:

DATE: DEC. 19/87

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5% Fe_2O_3

Atm.: H.P. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.07 Ω RUN#: 1

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1} \cdot cm^{-1}$)
0.0	——	1.8	——
4.95	——	0.73	——
7.49	——	0.57	——
10.03	0.305	0.465	0.772
11.3	0.284	0.43	0.789
12.57	0.265	0.405	0.791
13.84	0.247	0.38	0.797
15.11	0.230	0.35	0.821
16.38	0.214	0.33	0.823
17.65	0.199	0.30	0.865
18.92	0.186	0.28	0.886
20.19	0.174	0.265	0.892
21.46	0.164	0.25	0.911
22.73	0.154	0.23	0.963
24.0	0.146	0.21	1.043
25.27	0.139	0.195	1.112
26.54	——	0.175	——
27.81	——	0.140	——
29.08	——	——	——

wide: 0.871 ± 0.080

narrow: 0.939 ± 0.066

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5wt.% Fe_2O_3 DATE: DEC. 18/87

Additions made to sample: Atm.: H.P. Ar (gettered)

100g as-received + 7.87g Fe_2O_3 + 0.94g Fe powder

Total wt. of sample: 108.81g Total wt. w/crucible: init.- 157.85g

finl.- 157.67g

RUN#: 2 TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	127	0.0	1.92
1	88	4.95	0.77
1	68	7.49	0.60
1	48	10.03	0.50
1	38	11.3	0.46
1	28	12.57	0.425
1	18	13.84	0.395
1	08	15.11	0.365
1	998	16.38	0.34
1	988	17.65	0.315
1	978	18.92	0.295
1 (0.3)	968	20.19	0.275 (0.295)
1 (0.3)	958	21.46	0.26 (0.28)
1 (0.3)	948	22.73	0.24 (0.265)
1 (0.3)	938	24.0	0.22 (0.245)
1 (0.3)	928	25.27	0.20 (0.227)
1 (0.3)	918	26.54	0.18 (0.21)
1 (0.3)	908	27.81	0.16 (0.182)
1 (0.3)	899	BOTTOM ~~29.08~~	0.08 (0.11)
		Depth 28.9 mm	

CONDUCTIVITY CALCULATION:

SLAG SAMPLE: $1.05\ Fe/SiO_2$ with 5 wt.% Fe_2O_3

TEMPERATURE: 1300 °C ± 5°

DATE: DEC. 19/87

Atm.: H.P. Ar

$r_{ext.}$ = 0.08 Ω

RUN#: 2

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	1.92	—
4.95	—	0.77	—
7.49	—	0.60	—
10.03	0.305	0.50	0.726
11.3	0.284	0.46	0.747
12.57	0.265	0.425	0.768
13.84	0.247	0.395	0.784
15.11	0.230	0.365	0.807
16.38	0.214	0.34	0.823
17.65	0.199	0.315	0.847
18.92	0.186	0.295	0.865
20.19	0.174	0.275	0.892
21.46	0.164	0.26	0.911
22.73	0.154	0.24	0.963
24.0	0.146	0.22	1.043
25.27	0.139	0.20	1.158
26.54	—	0.18	—
27.81	—	0.16	—
29.08	—	—	—

wide - ~~0.939~~ | 0.859 ± 0.084

narrow - 0.935 ± 0.070

SLAG CONDUCTIVITY DETERMINATION

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5wt.% Fe_2O_3.

DATE: DEC. 19/87

Additions made to sample:

100g as-received + 7.87 g Fe_2O_3 + 0.94g Fe powder

Atm.: H.P. Ar (gettered)

Total wt. of sample: 108.81 g

Total wt. w/crucible: init.- 157.85g
finl.- 157.67g

RUN#: 3

TEMPERATURE: 1300°C ± 5°

SCALE (ohm)	DIAL READING	SLAG DEPTH (mm)	RESISTANCE (ohms)
3	127	0.0	1.95
1	88	4.95	0.78
1	68	7.49	0.61
1	48	10.03	0.51
1	38	11.3	0.47
1	28	12.57	0.44
1	18	13.84	0.40
1	08	15.11	0.375
1	998	16.38	0.35
1	988	17.65	0.325
1	978	18.92	0.30
1	968	20.19	0.28
1 (0.3)	958	21.46	0.26 (0.285)
1 (0.3)	948	22.73	0.245 (0.267)
1 (0.3)	938	24.0	0.23 (0.25)
1 (0.3)	928	25.27	0.21 (0.232)
1 (0.3)	918	26.54	0.19 (0.215)
1 (0.3)	908	27.81	0.16 (0.187)
1 (0.3)	899	BOTTOM ~~29.08~~	0.08 (0.11)
		Depth. 28.9 mm	

CONDUCTIVITY CALCULATION:

DATE: DEC. 19/87

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5wt.% Fe_2O_3

Atm.: HP. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.08 Ω RUN#: 3

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	1.95	—
4.95	—	0.78	—
7.49	—	0.61	—
10.03	0.305	0.51	0.709
11.3	0.284	0.47	0.728
12.57	0.265	0.44	0.736
13.84	0.247	0.40	0.772
15.11	0.230	0.375	0.780
16.38	0.214	0.35	0.793
17.65	0.199	0.325	0.812
18.92	0.186	0.30	0.845
20.19	0.174	0.28	0.870
21.46	0.164	0.26	0.911
22.73	0.154	0.245	0.933
24.0	0.146	0.23	0.973
25.27	0.139	0.21	1.069
26.54	—	0.19	—
27.81	—	0.16	—
29.08	—	—	—

wide - 0.832 ± 0.081

narrow - 0.906 ± 0.051

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 19/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5wt.% Fe_2O_3

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.(#1+2)
	RUN# 1	RUN# 2	RUN# 3	
0.0	1.8	1.92	1.95	1.860
4.95	0.73	0.77	0.78	0.750
7.49	0.57	0.60	0.61	0.585
10.03	0.465	0.50	0.51	0.483
11.3	0.43	0.46	0.47	0.445
12.57	0.405	0.425	0.44	0.415
13.84	0.38	0.395	0.40	0.388
15.11	0.35	0.365	0.375	0.358
16.38	0.33	0.34	0.35	0.335
17.65	0.30	0.315	0.325	0.308
18.92	0.28	0.295	0.30	0.288
20.19	0.265	0.275	0.28	0.270
21.46	0.25	0.26	0.26	0.255
22.73	0.23	0.24	0.245	0.235
24.0	0.21	0.22	0.23	0.215
25.27	0.195	0.20	0.21	0.198
26.54	0.175	0.18	0.19	0.178
27.81	0.140	0.16	0.16	0.150
~~29.08~~	Rext. 0.07 —	Rext 0.08 —	Rext 0.08 —	0.075

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 19/87

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5wt.% Fe_2O_3

Atm.: HP. Ar

TEMPERATURE: 1300°C ± 5°

$r_{ext.}$ = 0.075 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm) (#1+2)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	1.860	—
4.95	—	0.750	—
7.49	—	0.585	—
10.03	0.305	0.483	0.748
11.3	0.284	0.445	0.768
12.57	0.265	0.415	0.779
13.84	0.247	0.388	0.789
15.11	0.230	0.358	0.813
16.38	0.214	0.335	0.823
17.65	0.199	0.308	0.854
18.92	0.186	0.288	0.873
20.19	0.174	0.270	0.892
21.46	0.164	0.255	0.911
22.73	0.154	0.235	0.963
24.0	0.146	0.215	1.043
25.27	0.139	0.198	1.130
26.54	—	0.178	—
27.81	—	0.150	—
29.08	—	—	—

wide - 0.864 ± 0.084

narrow - 0.936 ± 0.068

SLAG CONDUCTIVITY DETERMINATION

DATE: DEC. 19/87

SUMMARY OF RESISTANCE MEASUREMENTS:

Atm.: H.P. Ar (gettered)

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5 wt.% Fe_2O_3

TEMPERATURE: 1300°C ± 5°

DEPTH (mm)	RESISTANCE (ohms)			AVG.
	RUN# 1	RUN# 2	RUN# 3	
0.0	1.8	1.92	1.95	1.89
4.95	0.73	0.77	0.78	0.76
7.49	0.57	0.60	0.61	0.593
10.03	0.465	0.50	0.51	0.492
11.3	0.43	0.46	0.47	0.453
12.57	0.405	0.425	0.44	0.423
13.84	0.38	0.395	0.40	0.392
15.11	0.35	0.365	0.375	0.363
16.38	0.33	0.34	0.35	0.340
17.65	0.30	0.315	0.325	0.313
18.92	0.28	0.295	0.30	0.292
20.19	0.265	0.275	0.28	0.273
21.46	0.25	0.26	0.26	0.257
22.73	0.23	0.24	0.245	0.238
24.0	0.21	0.22	0.23	0.220
25.27	0.195	0.20	0.21	0.202
26.54	0.175	0.18	0.19	0.182
27.81	0.140	0.16	0.16	0.153
~~29.08~~	~~Rext. 0.07~~	Rext. 0.08	Rext. 0.08	Rext. 0.08

SLAG CONDUCTIVITY DETERMINATION

CONDUCTIVITY CALCULATION:

DATE: DEC. 19/87

SLAG SAMPLE: L05 Fe/SiO_2 with 5wt.% Fe_2O_3

Atm.: H.P. Ar (gettered)

TEMPERATURE: 1300 °C ± 5°

$r_{ext.}$ = 0.08 Ω

DEPTH (mm)	CELL CONSTANT (cm^{-1})	RESISTANCE (ohm)	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$)
0.0	—	1.89	—
4.95	—	0.76	—
7.49	—	0.593	—
10.03	0.305	0.492	0.740
11.3	0.284	0.453	0.761
12.57	0.265	0.423	0.773
13.84	0.247	0.392	0.792
15.11	0.230	0.363	0.813
16.38	0.214	0.340	0.823
17.65	0.199	0.313	0.854
18.92	0.186	0.292	0.877
20.19	0.174	0.273	0.902
21.46	0.164	0.257	0.927
22.73	0.154	0.238	0.975
24.0	0.146	0.220	1.043
25.27	0.139	0.202	1.139
26.54	—	0.182	—
27.81	—	0.153	—
29.08	—	—	—

wide - 0.867 ± 0.088

narrow - 0.891 ± 0.044.

APPENDIX II

CALCULATED ELECTRICAL CONDUCTIVITY VALUES FOR ALL SAMPLES

SLAG CONDUCTIVITY DETERMINATION:

SUMMARY OF CONDUCTIVITY VALUES: DATE: DEC. 3/87

SLAG SAMPLE: 0.85 Fe/SiO_2 Atm.: HP. Ar

Additions made to sample: Total wt. of sample : 104.57

100g as-received + 4.57g SiO_2

Total wt. w/crucible: init.- 151.50 g Weight change: 0.06 g
finl.- 151.44 Depth of Slag: 29.0 mm

TEMP. (°C)	RUN(S) involved	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Wide Range*	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Narrow Range**
1250°C ± 5°	1	0.357 ± 0.012	0.358 ± 0.003
"	2	0.370 ± 0.010	0.368 ± 0.004
"	3	0.371 ± 0.009	0.371 ± 0.002
"	2 and 3	0.370 ± 0.010	0.369 ± 0.003 *
1300°C ± 5°	1	0.436 ± 0.017	0.437 ± 0.012
"	2	0.441 ± 0.010	0.444 ± 0.002
"	3	0.442 ± 0.013	0.443 ± 0.002
"	2 and 3	0.442 ± 0.011	0.443 ± 0.0016 *

*Wide Range - all points considered except extremes
**Narrow - points within approx. 5mm below midpoint of melt considered

- temp. probably too low for first run [illegible] temp. due to time taken to find the surface.

Analysis: Fe/SiO_2 = 0.843
Total CaO = 2.04 wt.%

SLAG CONDUCTIVITY DETERMINATION:

SUMMARY OF CONDUCTIVITY VALUES: DATE: DEC. 6/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt.% Fe_2O_3 addition Atm.: HP. Ar

Additions made to sample: Total wt. of sample : 109.80g

100g as-received + 4.57 SiO_2 + 5.23g Fe_2O_3

Total wt. w/crucible: init.- 159.51g
finl.- 159.34

Weight change: 0.17g
Depth of Slag: 30.35 mm.

TEMP. (°C)	RUN(S) involved	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Wide Range*	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Narrow Range**
1250°C ± 5°	1	0.555 ± 0.019	0.558 ± 0.006
"	2	0.551 ± 0.018	0.554 ± 0.004
"	3	0.535 ± 0.015	0.536 ± 0.007
"	1 and 2	0.552 ± 0.017	0.556 ± 0.005 *
1300°C ± 5°	1	0.722 ± 0.050	0.723 ± 0.013
"	2	0.698 ± 0.048	0.701 ± 0.020
"	3	0.660 ± 0.030	0.658 ± 0.010
"	1 and 2	0.708 ± 0.048	0.710 ± 0.013 *

*Wide Range - all points considered except extremes
**Narrow - points within approx. 5mm below midpoint of melt considered

– third run (#3) at both temperatures [illegible] significantly lower than other runs.
this maybe due to [illegible] made at too low a temp than [illegible]
[illegible] for more [illegible]

Analysis : Fe/SiO_2 = 0.937

SLAG CONDUCTIVITY DETERMINATION:

SUMMARY OF CONDUCTIVITY VALUES: DATE: DEC. 8/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 5 wt.% CaO addition Atm.: HP. Ar

Additions made to sample: Total wt. of sample : 109.80 g

100 g as-received + 4.57 g SiO_2 + 5.23 g CaO

Total wt. w/crucible: init.- 159.91 g Weight change: 0.33 g
finl.- 159.58 Depth of Slag: 30.35 mm

TEMP. (°C)	RUN(S) involved	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Wide Range*	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Narrow Range**
1250°C ± 5°	1	0.400 ± 0.014	0.401 ± 0.005
"	2	0.406 ± 0.016	0.407 ± 0.005
"	3	0.395 ± 0.014	0.397 ± 0.005
"	all	0.400 ± 0.014	0.402 ± 0.005 *
1300°C ± 5°	1	0.485 ± 0.017	0.498 ± 0.008
"	2	0.471 ± 0.013	0.481 ± 0.004
"	3	0.530 ± 0.033	0.559 ± 0.019
"	1 and 2	0.477 ± 0.014	0.489 ± 0.006 *

*Wide Range - all points considered except extremes
**Narrow - points within approx. 5mm below midpoint of melt considered

- run #3 at 1300°C significantly higher than other two runs - disregarded

Analysis: Fe/SiO_2 = 0.838

CaO addition = 3.88 wt.%

Total CaO = 6.0 wt.%

X

SLAG CONDUCTIVITY DETERMINATION:

SUMMARY OF CONDUCTIVITY VALUES: DATE: DEC. 20/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 10 wt.% CaO addition Atm.: HP. Ar

Additions made to sample: Total wt. of sample : 103.11g

90g as-received + 4.11g SiO_2 + 9.0g CaO

Total wt. w/crucible: init.- 152.47g Weight change: 0.93g

fin1.- 151.54 Depth of Slag: 28.7mm

TEMP. (°C)	RUN(S) involved	CONDUCTIVITY (ohm^{-1}.cm^{-1}) Wide Range*	CONDUCTIVITY (ohm^{-1}.cm^{-1}) Narrow Range**
1250°C ± 5°	1	0.443 ± 0.006	0.442 ± 0.0008
"	2	0.461 ± 0.012	0.458 ± 0.008
"	3	0.423 ± 0.006	0.425 ± 0.002
"	all	0.442 ± 0.007	0.442 ± 0.002 *
1300°C ± 5°	1	0.544 ± 0.013	0.546 ± 0.0017
"	2	0.502 ± 0.008	0.498 ± 0.006
"	3	0.498 ± 0.006	0.495 ± 0.006
"	2 and 3	0.500 ± 0.006	0.496 ± 0.004 *

*Wide Range - all points considered except extremes

**Narrow - points within approx. 5mm below midpoint of melt considered

Analysis: Fe/SiO_2 = 0.843

CaO addition = 6.18 wt.%

Total CaO = 8.3 wt.%

SLAG CONDUCTIVITY DETERMINATION:

SUMMARY OF CONDUCTIVITY VALUES: DATE: DEC. 21/87

SLAG SAMPLE: 0.85 Fe/SiO_2 with 15 wt.% CaO addition Atm.: HP. Ar

Additions made to sample: Total wt. of sample : 108.23g

90g as-received + 4.11g SiO_2 + 14.12g CaO

Total wt. w/crucible: init.- 155.38 g Weight change: 1.54g

finl.- 153.84 Depth of Slag: 29.8mm

TEMP. (^oC)	RUN(S) involved	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Wide Range*	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Narrow Range**
1250°C ± 5°	1	0.421 ± 0.004	0.423 ± 0.002
"	2	0.412 ± 0.004	0.414 ± 0.003
"	3	0.432 ± 0.006	0.431 ± 0.005
"	all	0.421 ± 0.003	0.423 ± 0.003 *
1300°C ± 5°	1	0.517 ± 0.004	0.515 ± 0.004
"	2	0.511 ± 0.007	0.514 ± 0.004
"	3	0.502 ± 0.006	0.503 ± 0.003
"	1 and 2	0.514 ± 0.005	0.514 ± 0.004. *

*Wide Range - all points considered except extremes

**Narrow - points within approx. 5mm below midpoint of melt considered

Analysis : Fe/SiO_2 = 0.845

CaO addition = 8.58 wt.%

Total CaO = 10.7 wt.%

SLAG CONDUCTIVITY DETERMINATION:

SUMMARY OF CONDUCTIVITY VALUES: DATE: DEC. 9/87

SLAG SAMPLE: 0.95 Fe/SiO_2 Atm.: HP. Ar

Additions made to sample: Total wt. of sample : 100.13g

100 g as-received + 0.13g SiO_2

Total wt. w/crucible: init.- 147.53 g Weight change: 0.04 g
fínl.- 147.49 Depth of Slag: 26.5 mm

TEMP. (°C)	RUN(S) involved	CONDUCTIVITY $(\text{ohm}^{-1}.\text{cm}^{-1})$ Wide Range*	CONDUCTIVITY $(\text{ohm}^{-1}.\text{cm}^{-1})$ Narrow Range**
1250°C ± 5°	1	0.530 ± 0.004 – too deep	0.533 ± 0.002
"	2	0.513 ± 0.011	0.509 ± 0.005
"	3	0.489 ± 0.008	0.487 ± 0.002
"	2 and 3	0.500 ± 0.009	0.497 ± 0.002 *
1300°C ± 5°	1	0.602 ± 0.015	0.603 ± 0.007
"	2	0.585 ± 0.016	0.589 ± 0.006
"	3	0.597 ± 0.015	0.603 ± 0.007
"	1 and 3.	0.599 ± 0.014	0.603 ± 0.006. *

*Wide Range - all points considered except extremes
**Narrow - points within approx. 5mm below midpoint of melt considered

Analysis: Fe/SiO_2 = 0.940

SLAG CONDUCTIVITY DETERMINATION:

SUMMARY OF CONDUCTIVITY VALUES: DATE: DEC. 11/87

SLAG SAMPLE: 0.95 Fe/SiO_2 with 5wt.% Fe_2O_3 addition Atm.: HP. Ar

Additions made to sample: Total wt. of sample : 105.13 g

100 g as-received + 0.13 g SiO_2 + 5.0 g Fe_2O_3

Total wt. w/crucible: init. - 156.10 g Weight change: 0.15 g

finl. - 155.95 Depth of Slag: 28.3 mm

TEMP. (°C)	RUN(S) involved	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Wide Range*	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Narrow Range**
1250°C ± 5°	1	0.744 ± 0.077	0.709 ± 0.026
"	2	0.693 ± 0.060	0.666 ± 0.015
"	3	0.693 ± 0.061	0.669 ± 0.022
"	2 and 3	0.693 ± 0.061	0.667 ± 0.018 *
1300°C ± 5°	1	0.805 ± 0.077	0.827 ± 0.057
"	2	0.769 ± 0.052	0.794 ± 0.033
"	3	0.801 ± 0.083	0.831 ± 0.056.
"	1 and 3	0.802 ± 0.080	0.828 ± 0.056 *

*Wide Range - all points considered except extremes
**Narrow - points within approx. 5mm below midpoint of melt considered

Analysis: Fe/SiO_2 = 1.029

SLAG CONDUCTIVITY DETERMINATION:

SUMMARY OF CONDUCTIVITY VALUES: DATE: DEC. 17/87

SLAG SAMPLE: 1.05 Fe/SiO_2 (actually 1.029 Fe/SiO_2) Atm.: HP. Ar

Additions made to sample: Total wt. of sample: 103.63 g

100g as-received + 2.69g Fe_2O_3 + 0.94g Fe powder

Total wt. w/crucible: init.-152.82 g Weight change: 0.10 g
finl.-152.72 Depth of Slag: ~27.5mm

TEMP. (°C)	RUN(S) involved	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Wide Range*	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Narrow Range**
1250°C ± 5°	1	0.542 ± 0.031	0.552 ± 0.021
"	2	0.534 ± 0.032	0.541 ± 0.018
"	3	0.508 ± 0.023	0.513 ± 0.013
"	1 and 2	0.537 ± 0.032	0.546 ± 0.020 *
1300°C ± 5°	1	0.736 ± 0.055	0.715 ± 0.021
"	2	0.742 ± 0.085	0.709 ± 0.029
"	3	0.765 ± 0.102	0.723 ± 0.027
"	1 and 2	0.738 ± 0.069	0.712 ± 0.025 *

*Wide Range - all points considered except extremes
**Narrow - points within approx. 5mm below midpoint of melt considered

Analysis: Fe/SiO_2 = 1.015

X

SLAG CONDUCTIVITY DETERMINATION:

SUMMARY OF CONDUCTIVITY VALUES: DATE: DEC. 19/87

SLAG SAMPLE: 1.05 Fe/SiO_2 with 5 wt.% Fe_2O_3 addition (actually 1.029 Fe/SiO_2) Atm.: HP. Ar

Additions made to sample: Total wt. of sample : 108.81g

100g as-received + 7.87g Fe_2O_3 + 0.94g Fe powder

Total wt. w/crucible: init.- 157.85 g Weight change: 0.18g

finl.- 157.67g Depth of Slag: ~28.5g

TEMP. (°C)	RUN(S) involved	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Wide Range*	CONDUCTIVITY ($ohm^{-1}.cm^{-1}$) Narrow Range**
1250°C ± 5°	1	0.795 ± 0.073	0.765 ± 0.022
"	2	0.760 ± 0.056	0.742 ± 0.022
"	3	0.763 ± 0.071	0.732 ± 0.020
"	2 and 3	0.761 ± 0.063	0.736 ± 0.020 *
1300°C ± 5°	1	0.871 ± 0.080	0.939 ± 0.066
"	2	0.859 ± 0.089	0.935 ± 0.070
"	3	0.832 ± 0.081	0.906 ± 0.051
"	1 and 2	0.864 ± 0.084	0.936 ± 0.068 *

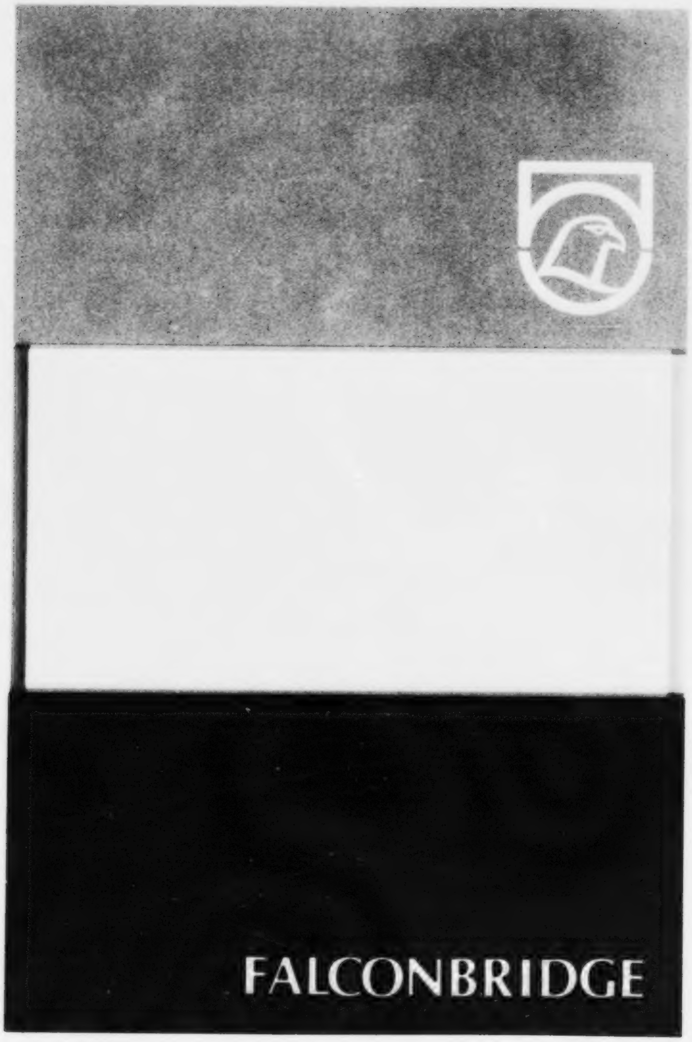
*Wide Range - all points considered except extremes

**Narrow - points within approx. 5mm below midpoint of melt considered

Analysis: Fe/SiO_2 = 1.099

Volume

5



FALCONBRIDGE

FALCONBRIDGE LIMITED

METALLURGICAL TECHNOLOGY CENTRE

TO DEVELOP A CLEAN SMELTING PROCESS FOR HIGHLY ROASTED COPPER-NICKEL CALCINES AND TO IMPROVE METAL RECOVERY

PART E:

FINAL REPORT

(SUMMARY OF PARTS A THROUGH D)

by

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EXECUTIVE SUMMARY

In order to meet environmental requirements and to cut operating costs, a new smelting process was commissioned for Falconbridge Limited's Sudbury Operation in 1978. The current process consists of two fluid bed roasters, two electric furnaces, a converter aisle, and an acid plant. The new smelter was designed to operate at a roaster sulphur elimination of 50%; this has recently been increased to 60%. Increasing the degree of roast even further would give an additional decrease in sulphur dioxide emissions by increasing the fraction converted to sulphuric acid.

When the degree of roast is increased, however, more heavily oxidized calcines are produced. This results in higher matte grades in the electric furnace which are detrimental to smelter metal recoveries. The countermeasure is to smelt under more intensive reducing conditions. In the presence of coke a dense metallic phase forms during the smelting of the calcine. This leads to a buildup of metal on the furnace hearth, thus, reducing the capacity of the furnace and interfering with the tapping operation.

In order to develop and implement the proposed "clean smelting" regime, there must be a clear understanding of the processes that take place in the charge to the electric furnace, the behaviour of coke in the reduction process, and the properties of the matte and slag present in the furnace. This contract was divided into four distinct sections:

1. Thermogravimetric-Gas Chromatographic Analysis of Smelting
2. Matte Density Studies
3. Metallic Phase Saturation Boundary, and
4. Physical Properties of Smelting Slags (Electrical Conductivity of Slags).

The data generated from this work will enable Falconbridge Limited to:

1. increase sulphur dioxide recovery and reduce sulphur dioxide emissions,
2. improve recoveries of nickel and cobalt, and
3. maintain a continuous and reliable electric furnace operation.

In the first part of the contract, a thermogravimetric analyzer - gas chromatograph combination was used to examine the behaviour of electric furnace feed mixtures (i.e. calcine and coke). The sample heating rate was selected to reflect the residence time in the smelting furnace. As the temperature was increased, specific reactions that occurred were identified according to temperature of occurrence, quantity reacted, rate of reaction, and composition of the gaseous products. Additional samples were examined by arresting the process at various temperatures. The condensed phase composition was determined by chemical analysis and sections were examined metallographically and with electron-probe micro-analysis. The data from this testwork, in conjunction with fundamental thermodynamic principles, were applied in order to determine the sequence of chemical reactions encountered in a unit of charge as it descends from the freeboard to the liquid slag. Heating by slag resistance in an electric smelting furnace establishes a natural temperature gradient, from

approximately 500°C near the freeboard to 1230°C at the slag level. The low temperature reactions occur partly in contact with ingress air, and the high temperature reactions occur at a greater depth within the bed where the oxygen supply is limited by both the need for diffusion into the charge layer and the increasing reactivity of coke at higher temperatures. The effect of different levels of coke and lime additions on the smelting process were also examined.

In the second part of the contract, a bottom-weighing Archimedean technique was used to determine the densities of twenty different copper-nickel mattes. The copper to nickel mass ratios were fixed at 1:1 and the matte grades were varied between 13 and 57%. The iron to oxygen mass ratios of the mattes were approximately 16:1, which is typical of industrial mattes. Density measurements were determined in the 1100-1300°C temperature range. Industrially, density data are important for a variety of reasons. Density data are required in the analyses of reaction rates that occur in sulphide smelting and converting processes. For example, they can be used to establish the concentration of the melt in terms of unit volume. This can be used to formulate natural convective effects that arise from density changes resulting from metallurgical reactions. Knowledge of densities could also lead to a better understanding of the phenomenon that give rise to the presence of a solid magnetite phase in smelting and converting vessels.

The objective of the third part of the contract was to identify the restrictions placed on coke reduction because of metal precipitation in the matte. Over-reduction by coke results in the formation of excessive quantities of metal which precipitate from the matte phase. In the coke reduction zone, the appearance of the metallic phase fixes the thermodynamic conditions with respect to the oxygen potential of the system. This limit is critical to recovery because the nickel and cobalt losses in the slag are closely connected to the oxygen potential. In the bulk matte zone, metal precipitation causes hearth accretions which reduce the furnace capacity. A laboratory study was initiated in order to yield matte-metal equilibration data at temperatures ranging from 1000 to 1300°C. The compositions of the mattes (Ni-Cu-Fe-S-O) were in the range encountered in Falconbridge matte smelting utilizing increased degrees of roast. The effect of different Ni/Cu ratios on the experimental results were also examined.

The electrical conductivities of smelting slags were determined in the fourth part of the contract. A laboratory-scale crucible-probe conductivity cell was used for the determinations. The parameters investigated include: temperature, Fe/SiO_2 ratio, lime content, and Fe_2O_3 additions to the slag. These parameters were varied over the range applicable to electric furnace smelting at increased coke rates. From an industrial perspective, electrical conductivities are needed in order to predict electric furnace behaviour as the slag chemistry is altered.

SOMMAIRE

Afin de répondre aux exigeances environnementales et de réduire les coûts d'exploitation, un nouveau procédé de fusion a été commandé en 1978 pour l'installation de Sudbury de la compagnie Falconbridge Limited. Le procédé actuel comporte deux fours à lit fluidisé, deux fours électriques, un convertisseur et une usine de fabrication d'acide. La nouvelle fonderie a été conçue pour supprimer 50% du soufre dans les fours de grillage; ce chiffre a récemment été augmenté à 60%. Un deuxième augmentation de l'intensité de grillage réduirait davantage les émissions de bioxide de soufre en raison de l'augmentation de la proportion convertie en acide sulfurique.

Mais l'augmentation de l'intensité de grillage produit des concentrés calcinés plus oxydés donnant lieu à des mattes de teneur plus élevée dans le four électrique. Ceci agit au détriment du rendement métal de la fonderie. La contre-mesure consiste en la fusion de minerais dans des conditions plus intensives de réduction. En présence du coke, toutefois, il se forme une phase métallique dense lors de la fusion du calciné, ce qui cause une accumulation de métal au sole du four diminuant la capacité du four et nuisant à la coulée.

Afin de mettre au point et de mettre en pratique le régime de "fonte salubre" envisagé, il est nécessaire de bien comprendre d'abord l'action qui se poursuit dans la charge du four électrique; puis le comportement du coke lors du processus de réduction et enfin les propriétés de la matte et de la scorie qui sont présentes dans le four. Le contrat a été divisé en quatre parties distinctes:

1. l'analyse de la fusion à partir d'une combinaison de thermogravimétrie et de chromatographie en phase gazeuse;
2. les études sur la densite de mattes;
3. la détermination du seuil de saturation de la phase métallique;
4. l'étude des propriétés physiques des scories de fonte (conductivité électrique des scories).

Les données obtenues lors de ces travaux permettront à la compagnie Falconbridge Limited de:

1. augmenter le taux de récupération de bioxide de soufre et d'en réduire la quantité émise dans l'atmosphère;
2. améliorer la quantité récupérée de nickel et de cobalt;
3. maintenir un fonctionnement continu et efficace des fours électriques.

Lors de la première partie du contrat, une combinaison de thermogravimétrie et de chromatographie en phase gazeuse a été utilisée pour étudier le comportement des mélanges concentrés destinés au four électrique (c-à-d les calcinés et le coke). Le degré de chauffage de l'échantillon a été choisi en fonction de la durée du traitement métallurgique dans le four de fusion. A mesure que la température a été augmentée, les réactions ayant lieu ont été précisées selon la température à laquelle elles se produisaient, la quantité participant a la réaction, la vitesse de réaction et la composition des gazs qui en résultaient. D'autres échantillons ont été examinés en arrêtant le processus à des températures données. La composition des phases condensées a été déterminée au moyen d'analyses chimiques et certaines sections ont fait l'objet d'un examen métallographique et d'une micro-analyse avec sonde électro-métrique. Les données obtenues lors de ces travaux d'essai ainsi que les principes fondamentaux de thermodynamique ont été utilisés afin de déterminer l'ordre des réactions chimiques qui se produisent au sein d'une charge donnée au cours de sa progression du franc-bord jusqu'à la scorie liquide. Le chauffage utilisant la résistance de la scorie d'un four électrique produit une progression naturelle de températures allant d'environ 500°C près du franc-bord jusqu'à 1230°C au niveau de la scorie. Les réactions à basse température se produisent partiellement au contact de l'air et les réactions à haute température se réalisent à une plus grande profondeur dans le lit du four où la quantité d'oxygène est restreinte. Cette restriction est causée, d'une part, par la diffusion obligatoire de l'oxygène dans la couche de la charge, et, d'autre part, par la plus grande réactivité du coke à des température plus élevées. Les effets de différentes quantités de coke et de chaux sur le processus de la fusion ont aussi été examinés.

Lors de la deuxième partie du contrat, la densité de vingt différents échantillons de mattes de cuivre-nickel a été déterminée par l'application du principe d'Archimède à un système de pesage par en bas. Les proportions par masse de cuivre/nickel étaient égales (1:1) tandis que celles de fer/oxygène étaient d'environ 16:1, ce qui est typique des mattes industrielles. La qualité de la matte variait de 13% a 57%. Les mesures de densité ont été déterminées à des températures allant de 1100°C à 1300°C. Ces données jouent un rôle important dans une perspective industrielle pour plusieurs raisons. Premièrement, les données de densité sont nécessaires aux analyses de la rapidité des réactions qui se produisent lors de la fusion des sulfures et du processus de conversion. Par exemple, elles peuvent être utilisées pour établir la concentration de la fonte exprimée en fonction d'unité de volume. Ce chiffre peut ensuite servir à calculer les effets de la convection naturelle lors des changements de densité causés par les réactions métallurgiques. Deuxièmement, la connaissance des densités peut mener à une meilleure compréhension des phénomènes qui provoquent la formation d'une phase de magnétite solide dans les récipients de fusion et de conversion.

Le but de la troisième partie du contrat a été de repérer les restrictions apportées au degré de réduction du coke en raison de la précipitation de métaux dans la matte. La sur-réduction du coke résulte en la formation de quantités excessives de métaux qui se précipitent de la matte. Dans la zone de réduction du coke, la manifestation de la phase métallique fixe les conditions thermodynamiques par rapport au potentiel en oxygene du système. Cette limite est cruciale au rendement puisque les pertes de nickel et de cobalt dans les scorie sont étroitement liées au potentiel en oxygène. Dans la zone de mattes en vrac, les précipitations de métaux causent des accumulations au sole qui réduisent la capacité du four. Une étude en laboratoire a été effectuée afin de déterminer les données des matte-métaux équilibrées à des températures de 1000 à 1300°C. Les compositions des mattes (Ni, Cu, Fe, S, O) se situaient dans les limites obtenues lors de la fusion de mattes à des températures plus élevées de grillage à l'usine de Falconbridge. De plus, les effets de différents rapports nickel/cuivre sur les données expérimentales ont été examinés.

La conductivité des scories de fusion a été déterminée lors de quatrième partie du contrat. Pour ce faire, une cellule conductive en forme de creuset-sonde fabriquée de molybdène et qui était de grandeur laboratoire a été utilisée. Les paramètres étudiés étaient les suivants: le rapport de Fe/SiO_2, la quantité de chaux et les additions de Fe_2O_3 à la scorie. Ces paramètres se situent dans la limite applicable à la fusion dans un four électrique utilisant des quantités plus importantes de coke. Dans une perspective industrielle, les données de conductivité électrique sont nécessaires afin de prédir le fonctionnement des fours électriques à mesure que change la composition chimique de la scorie.

INTRODUCTION

Due to environmental and economic considerations, a new smelting process was commissioned for Falconbridge Limited's Sudbury Operation in 1978. The current process consists of two fluid bed roasters, two electric furnaces, a converter aisle, and an acid plant. The new smelter was designed to operate at a roaster sulphur elimination of 50%. Recently, this value has been increased to 60%. Operating at even higher degrees of roast is attractive as a means of improving the control of sulphur distribution in the plant. This advantage must be weighed against the possibility of higher metal loss to the electric furnace slag phase. Before the 'clean smelting' regime can be implemented there must be a clear understanding of the processes that take place in the charge to the electric furnace, the behaviour of coke in the reduction process, and the properties of the matte and slag present in the furnace. This contract was divided into four distinct sections:

1. Thermogravimetric-Gas Chromatographic Analysis of Smelting
2. Matte Density Studies
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The data generated from this work will enable Falconbridge Limited to:

1. increase sulphur dioxide recovery and reduce sulphur dioxide emissions,
2. improve recoveries of nickel and cobalt, and
3. maintain a continuous and reliable electric furnace operation.

The four sections are summarized below.

THERMOGRAVIMETRIC-GAS CHROMATOGRAPHIC ANALYSIS OF SMELTING

In the electric furnace, the smelting of calcine occurs in a series of stages:

1. heating of the charge (up to 950°C);
2. sulphide fusion and reduction by coke (950-1150°C);
3. matte-slag separation by settling (1150-1250°C);
4. recycle converter slag reduction (1200°C) and
5. matte accumulation in the hearth (1100°C).

In this part of the contract, the first two stages of smelting were investigated. In particular the sequence of reactions and the gaseous products evolved were determined. For this purpose four variables were assigned, namely:

1. degree of sulphur elimination from the calcine (50-75%);
2. coke addition (0-5%);
3. gas atmosphere (nitrogen and air) and
4. lime addition (0-15%).

The behaviour of calcine mixtures was studied during heating by a thermogravimetric analyzer-gas chromatograph combination. This method provides a correlation of mass changes and gas compositions with temperature. Chemical reactions are identified according to the temperature range of occurrence, reaction rate, and extent. As this method alone does not positively identify all chemical reactions, other techniques were employed in order to obtain more comprehensive data. During several tests the heating was arrested and the samples were examined by optical, chemical, micrographic, or electron microprobe analysis.

The sequence of smelting reactions that occur in the electric furnace can be classified according to the temperature range of occurrence as shown in Figure 1 (N_2 atmosphere-with and without lime addition) and in Figure 2(air atmosphere). Many similar reactions proceed under both oxidizing and neutral conditions, but if a supply of gaseous oxygen is available then the air-charge interaction becomes the dominant feature of the system. The important high temperature smelting reactions occur in the absence of air. These consist primarily of rapid oxide reduction by coke and secondarily, reduction by iron sulphide. The addition of lime to the system eliminated SO_2 discharge by stabilizing the sulphur as $CaSO_4$ or CaS.

The tests using nitrogen more closely represent the sequence in the electric furnace because oxygen supply in the calcine layer is restricted by the need for gas diffusion downwards against the rising stream of CO and CO_2 from the fusion zone. Figure 1 represents a graphic display of reactions that occur within a vertical section of the charge layer in an electric furnace. This can be visualized as a series of reaction zones encountered by a unit of charge as it descends from the freeboard to the slag.

To obtain high pay-metal recoveries during the smelting of highly roasted concentrates it is necessary to maximize coke utilization. Coke burnoff by contact with ingress air diminishes reductant availability and may result in high furnace freeboard temperatures. Productive coke involvement in electric smelting is primarily in the matte-assisted reduction of oxides. These reactions are extremely rapid and are tolerant of different coke feeds. High temperature smelting reactions are limited by coke supply, up to the 5% addition level examined. Reductant consumption within this regime is complete and rapid.

Environmental considerations favour the elimination of sulphur from the concentrate prior to smelting. Two characteristics of highly roasted calcines have been identified: lower availability of sulphur and higher input of oxygen. Increased desulphurization is achieved by roasting at higher temperatures. High temperatures aid in depressing the formation of metal sulphates in the calcine. Sulphates contribute directly to SO_3 and SO_2 formation in the electric furnace by undergoing thermal decomposition. Any decrease in sulphate formation in the roasters is beneficial in terms of lower SO_2 formation and in lower oxygen input to smelting.

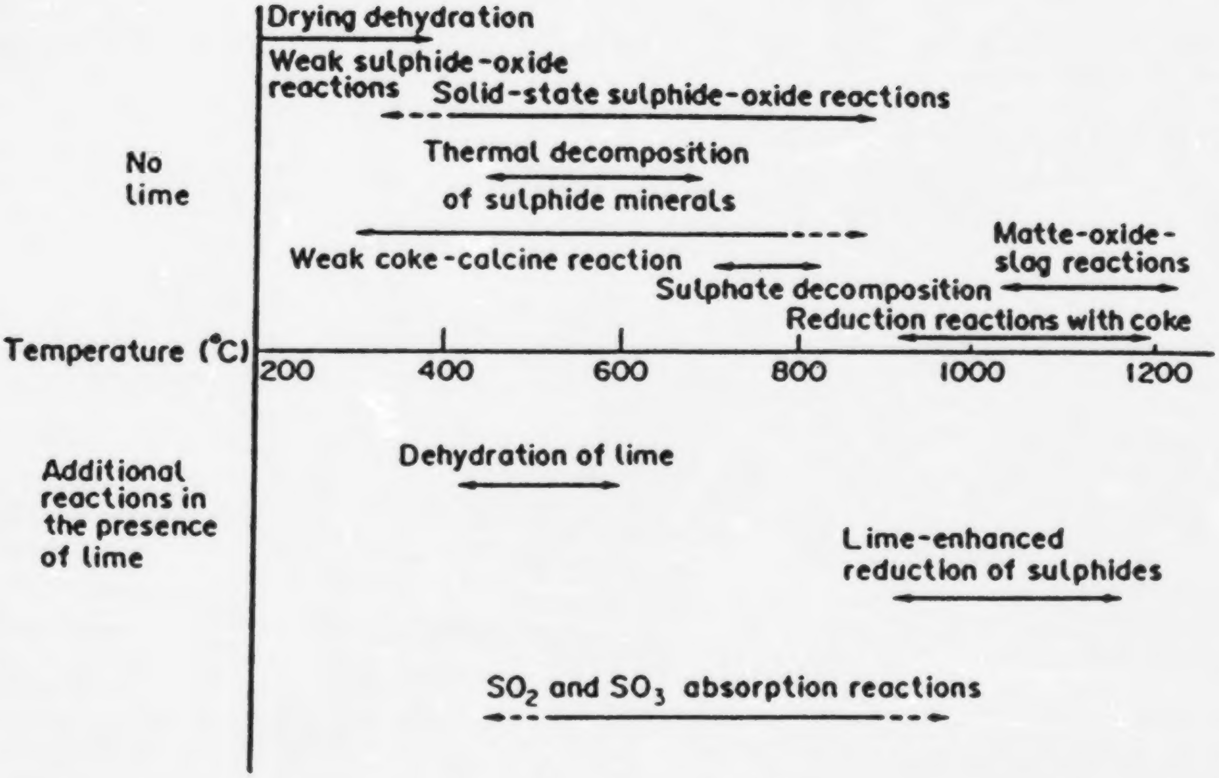
Drying dehydration
Weak sulphide-oxide reactions
Solid-state sulphide-oxide reactions
No lime
Thermal decomposition of sulphide minerals
Matte-oxide-slag reactions
Weak coke-calcine reaction
Sulphate decomposition
Reduction reactions with coke
Temperature (°C)
200
400
600
800
1000
1200
Dehydration of lime
Additional reactions in the presence of lime
Lime-enhanced reduction of sulphides
SO2 and SO3 absorption reactions

Figure 1. Smelting Reactions Under a Nitrogen Atmosphere

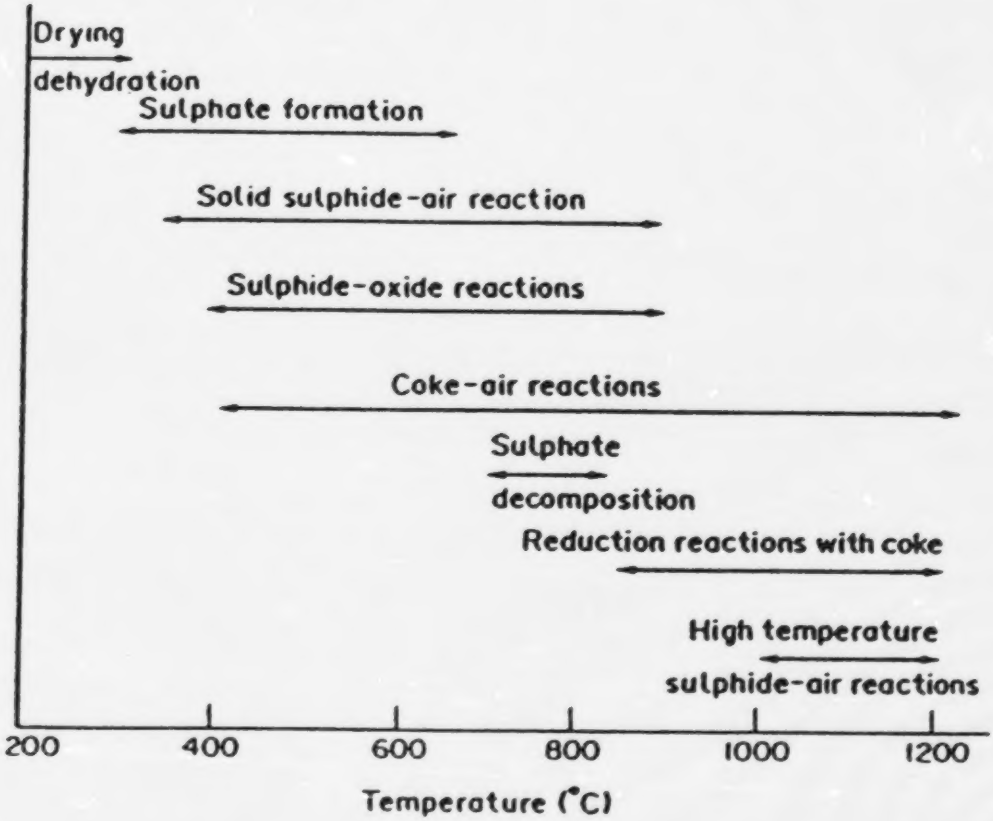

Figure 2. Smelting Reactions Under an Air Atmosphere

DENSITIES OF MOLTEN COPPER-NICKEL MATTES

Industrially, accurate density data are desired for a variety of reasons. In conventional copper-nickel converting, the quantity of matte being processed is usually recorded by the number of ladles handled. Although the volume of each ladle is known, the mass of matte in each ladle is usually estimated, since the density of the matte is unknown. Therefore, matte density data is required to improve the accuracy of material balances in the smelter. Also, density data leads to a better understanding of the phenomena which give rise to the presence of a solid magnetite phase in the smelting vessel. Density data are needed in order to estimate the time required for a matte droplet to settle from the slag phase. From a theoretical perspective, density data is useful in explaining the structure of sulphide melts.

The limited amount of density data for commercial Cu-Ni mattes is due to the numerous difficulties encountered when working with these types of systems. The more important of these are:

1. changes in specimen composition due to sulphur evolution from the matte, and

2. interfacial tension effects between the molten matte specimen and the density probes.

In this work, a bottom-weighing Archimedean technique, previously developed at the University of Toronto was used to measure the density of 20 different Cu-Ni mattes as a function of temperature and composition. This section of the contract was sub-contracted to the University of Toronto. This work is based on the Master of Applied Engineering thesis of Mr. J. Hryn.

The compositions of the matte specimens investigated are essentially in the five component Cu-Ni-Fe-S-O system. By setting the Cu/Ni mass ratio to unity and the Fe/O mass ratio to 16, the system is reduced to three components, which is more convenient to represent the density data. The Fe/O mass ratio of 16 is of particular interest to commercial smelting operations. Since some of the specimens were obtained from Falconbridge Limited, they contain a small amount of cobalt (a few tenths of a percent). With respect to the sulphur and oxygen in the mattes, cobalt behaves more like iron than either copper or nickel. Therefore, it was assumed that grouping the small amount of cobalt with the iron would not significantly affect the presentation of the results.

Figures 3 and 4 show typical density data obtained in this study. Based on a linear regression of the data, the density, standard error of estimate, the correlation coefficient ("R"), and the temperature coefficient ("Alpha") for each matte specimen are summarized in Table 1. Since the correlation coefficient is close to unity, it can be assumed that the density of each matte specimen varies almost linerarly with temperature.

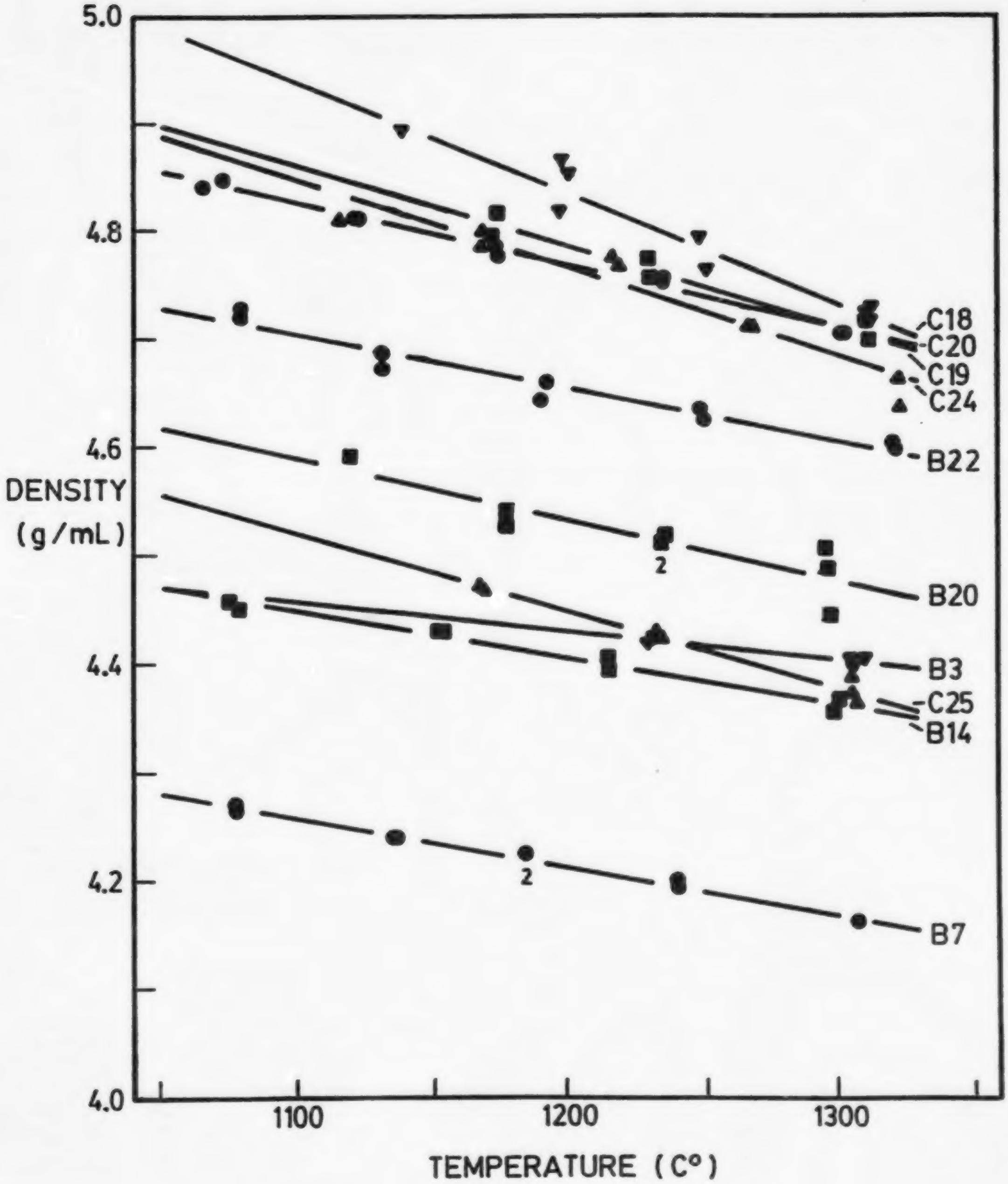

Figure 3. Density Data as a Function of Temperature

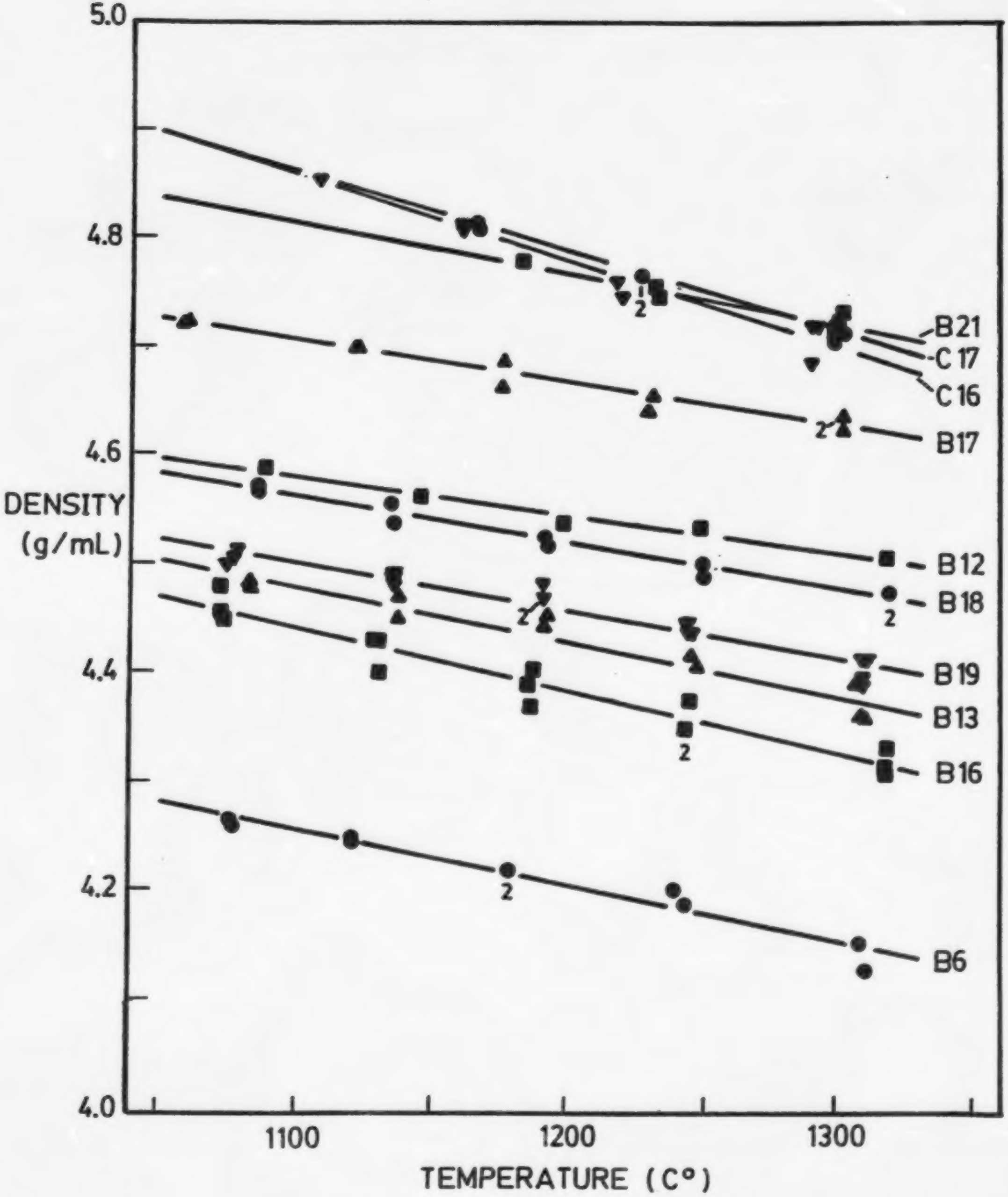

Figure 4. Density Data as a Function of Temperature

TABLE 1. Densities of the Matte Specimens

SPECIMEN NUMBER	DENSITY (g/mL) 1100°C	1200°C	1300°C	STD ERROR OF ESTIMATE (g/mL)	R	ALPHA x1000
B3	4.459	4.432	4.404	0.004	0.954	0.275
B6	4.258	4.207	4.155	0.010	0.979	0.512
B7	4.260	4.216	4.172	0.003	0.996	0.444
B12	4.580	4.546	4.512	0.005	0.988	0.340
B13	4.477	4.428	4.379	0.011	0.943	0.491
B14	4.450	4.407	4.364	0.007	0.987	0.426
B16	4.441	4.384	4.327	0.014	0.968	0.574
B17	4.706	4.668	4.629	0.008	0.977	0.385
B18	4.562	4.521	4.479	0.007	0.984	0.418
B19	4.503	4.459	4.414	0.010	0.970	0.444
B20	4.587	4.532	4.477	0.018	0.888	0.547
B21	4.814	4.768	4.723	0.008	0.948	0.454
B22	4.705	4.656	4.607	0.011	0.975	0.490
C16	4.861	4.787	4.714	0.005	0.995	0.737
C17	4.858	4.779	4.700	0.014	0.974	0.789
C18	4.941	4.838	4.736	0.016	0.973	1.028
C19	4.860	4.788	4.716	0.016	0.965	0.719
C20	4.827	4.770	4.712	0.005	0.996	0.576
C24	4.849	4.766	4.684	0.018	0.963	0.828
C25	4.520	4.451	4.382	0.006	0.992	0.690

Specimens received from Falconbridge Limited.

SPECIMEN NUMBER	COMPOSITIONS (mass %) Cu+Ni	Fe+O(+Co)	S	RATIOS Cu/Ni	Fe(+Co)/O
B3	35.9	35.8	28.3	1.02	18.9
B6	16.6	53.3	30.1	0.99	14.1
B7	20.3	51.9	27.8	0.98	14.4
B12	24.5	49.3	26.2	0.97	20.3
B13	26.6	45.7	27.7	0.98	18.2
B14	29.5	42.4	28.1	0.97	17.6
B16	33.1	38.2	28.7	0.99	17.8
B17	33.0	41.6	25.4	0.96	21.1
B18	35.2	37.3	27.5	0.97	19.1
B19	38.3	33.1	28.6	0.98	20.3
B20	15.7	58.8	25.5	0.94	16.6
B21	23.7	52.1	24.2	0.94	23.4
B22	28.1	46.4	25.5	0.99	21.1

Synthesized matte specimens.

SPECIMEN NUMBER	COMPOSITIONS (mass %) Cu+Ni	Fe+O	S	RATIOS Cu/Ni	Fe/O
C16	44.4	30.0	25.6	0.97	23.8
C17	46.8	27.3	25.9	1.01	18.7
C18	50.0	23.7	26.3	1.01	23.3
C19	53.3	20.0	26.7	0.98	32.7
C20	57.0	16.3	26.8	0.88	36.6
C24	29.6	46.8	23.6	1.01	25.9
C25	13.3	60.9	25.8	0.99	27.0

An examination of Table 1 reveals that the "Alpha" values (temperature coefficient of density) vary considerably over the range of composition investigated. The data do not indicate any significant correlation with either (%Cu +%Ni) or with %S. However, since the "Alpha" values are small, the relative errors associated with them are large. Nevertheless, "Alpha" is assumed to be independent of composition.

An overall empirical equation of density "D" (g/mL) as a function of sulphur content "S" (%S), matte grade "G" ($\leq$(%Cu + %NI)), and temperature "t" (°C) has been determined to be:

$$D = 6.532 - 0.0856\ S + 0.0097\ G + 0.00049\ (12\overset{0}{\underset{\wedge}{0}}-t)$$

The standard deviation for this equation is 0.0496 g/mL.

The bottom-weighing technique used in this investigation offers many advantages over other techniques used to determine densities of molten sulphides. Problems associated with surface tension effects can be eliminated using the two-bob approach. Composition changes due to sulphur evolution can be detected because the specimen weight is continuously being monitored. Also, because the specimen and not the bob is being weighed, the bob density can be less than the specimen density, since the bob can be forced into the melt. Therefore, the bob material can be selected for its chemical inertness with respect to the specimen, and not for its particular density.

The largest sources of error in this study are chemical analyses of specimen compositions and measurement errors. With the present method, the expected accuracy of the data is better than +/- 0.5%. This value is primarily based on the precision to which the bob volume was determined during calibration, and the accuracy to which the weight of displaced matte can be measured during experimentation.

METALLIC PHASE SATURATION BOUNDARY IN THE Ni-Cu-Fe-S SYSTEM BETWEEN 1000 AND 1300°C

As previously discussed, increasing the degree of roast is environmentally attractive because more of the sulphur in the concentrate can be fixed as sulphuric acid. When the degree of roast is increased, however, more heavily oxidized calcines are produced. This results in higher matte grades in the electric furnace which are detrimental to smelter metal recoveries. The countermeasure is to smelt under more intensive reducing conditions. In the presence of coke a dense metallic phase forms during the smelting of the calcine. This leads to a buildup of metal on the furnace hearth, thus, reducing the capacity of the furnace and interfering with the tapping operation.

This part of the contract was initiated in order to yield matte-metal equilibration data at temperatures ranging from 1000 to 1300°C. The compositions of the mattes (Ni, Cu, Fe, S) were in the range encountered in Falconbridge matte smelting utilizing increased degrees of roast. The tests were performed in sealed tubes and metallics were added in the form of a ferronickel alloy. The equilibration reaction between matte and metallics resulted in the formation of a new metallic phase in equilibrium with molten matte. The analysis of these mattes and the new metallic phases provided the data necessary to construct tie-lines between the two phases. Industrially, it is desirable to ascertain the location of the matte-metal saturation boundary. This boundary represents a condition of minimum oxygen potential at which point slag losses of nickel and cobalt are at their lowest.

Another objective was the estimation of the liquidus temperatures. This information is of value in predicting alloy formation at various temperatures as there is a vertical temperature gradient throughout the electric furnace.

Typical results obtained in this study are presented in Figures 5 and 6. Tie-lines are omitted from the diagrams for the sake of clarity. Results by Sobolev et al. are included for comparison purposes. As metal saturation is reached, a solid Fe-(Ni+Cu+Co) alloy precipitates. Further additions of coke results in an increase in the mass of metallics relative to liquid matte.

A schematic diagram illustrating the effects of coke additions and degrees of roast is shown in Figure 7. The composition of alloy in equilibrium with liquid matte traverses towards the Fe corner as the oxygen potential decreases. The alloy composition in equilibrium with liquid matte is a function of the oxygen potential of the system, which decreases with coke addition. At any metallics composition, the system oxygen potential is fixed by the matte-slag-alloy equilibrium; thus, the matte grade and oxygen solution capacity are also fixed. In the smelting furnace the metallized matte sinks down to the hearth, acting as a reductant for metal oxides recycled in converter slag.

The operation of commercial electric furnaces requires an efficient utilization of coke additions and the minimization of nickel losses to the slag. Accurate saturation boundary data are required for both of these purposes.

ELECTRICAL CONDUCTIVITY MEASUREMENTS OF ELECTRIC FURNACE SMELTING SLAGS

This section was subcontracted to the University of Toronto. The work was performed by M. H. Tseng under the auspices of Prof. J. M. Toguri.

The relationship between a slag's electrical conductance, composition and liquidus temperature is important from an industrial perspective. Electric furnace parameters and mode of furnace operation depend on the electrical conductivity of the slag.

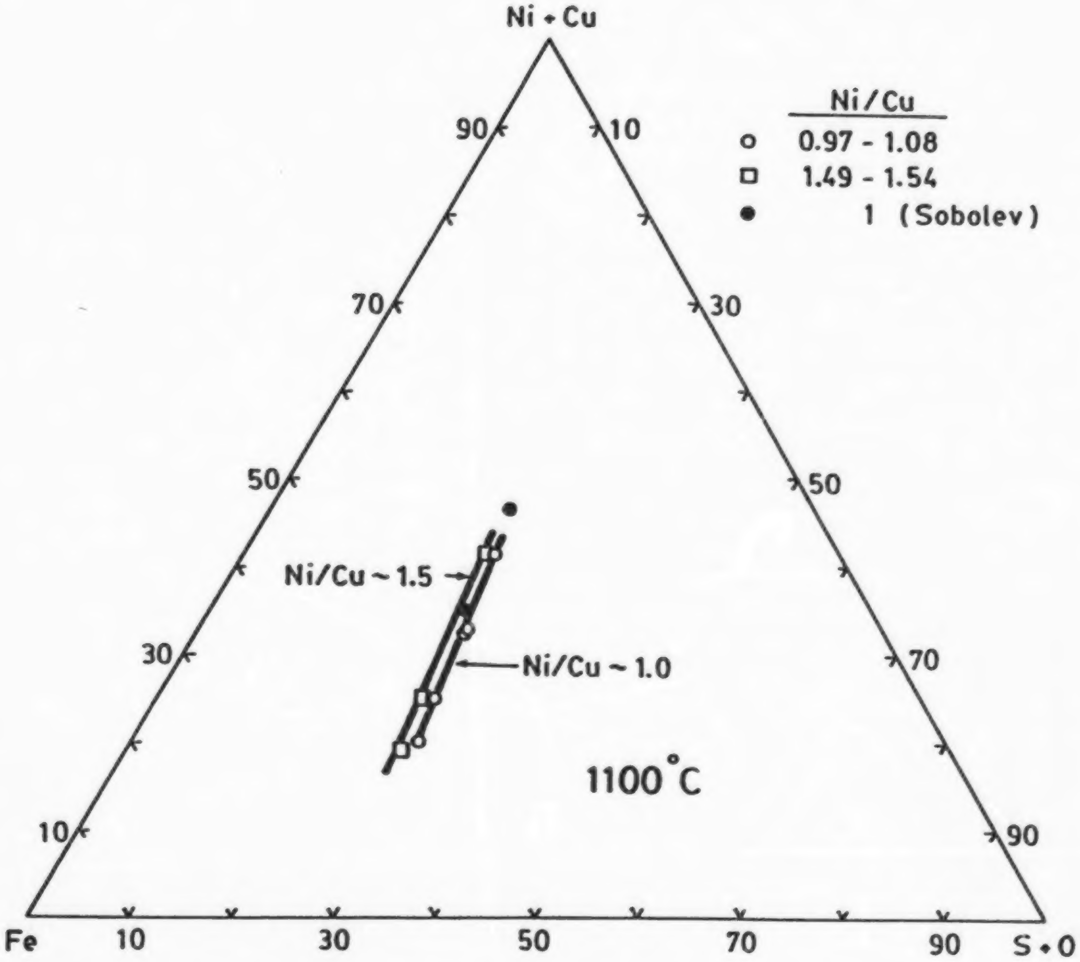

Figure 5. The Effect of the Ni/Cu Ratio on the Matte-Metal Saturation Boundary at 1100C.

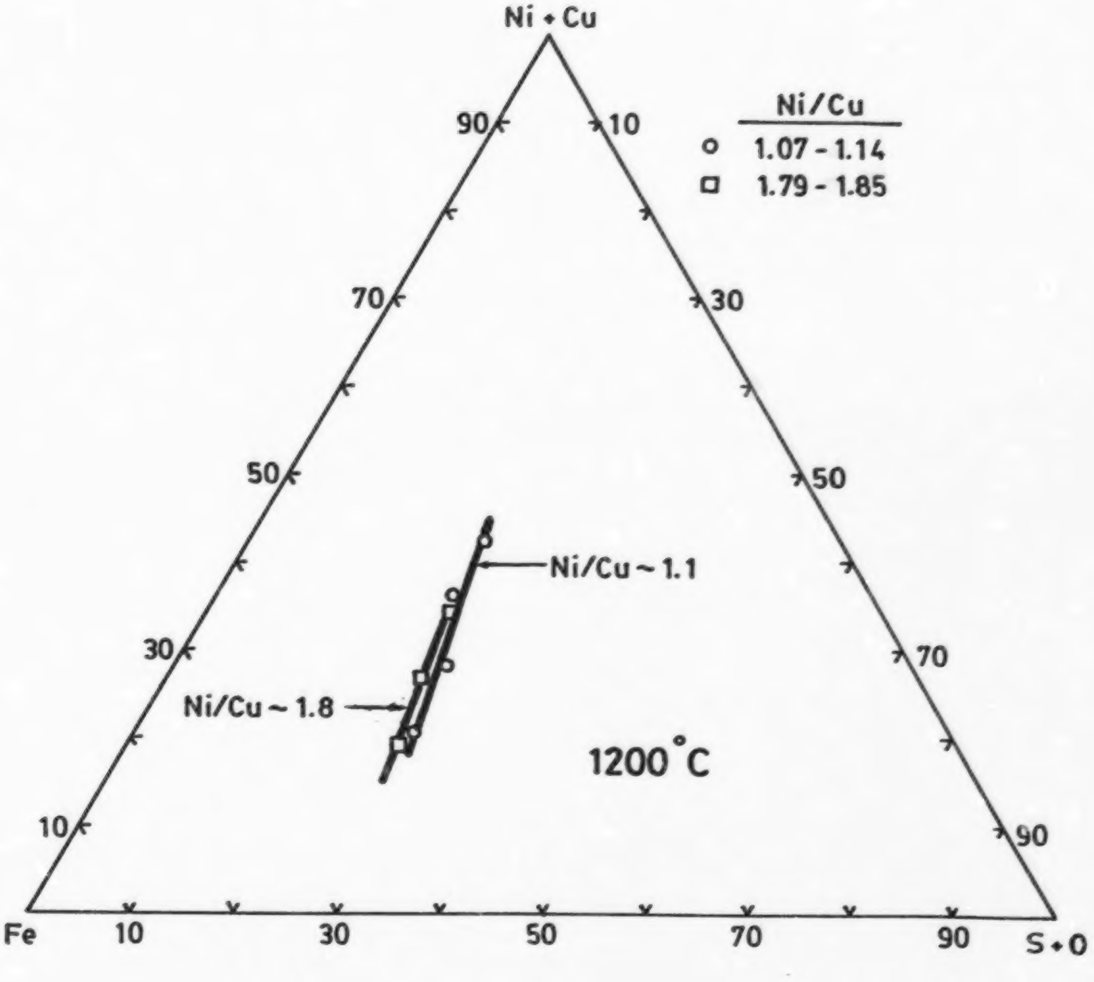

Figure 6. The Effect of the Ni/Cu Ratio on the Matte-Metal Saturation Boundary at 1200°C.

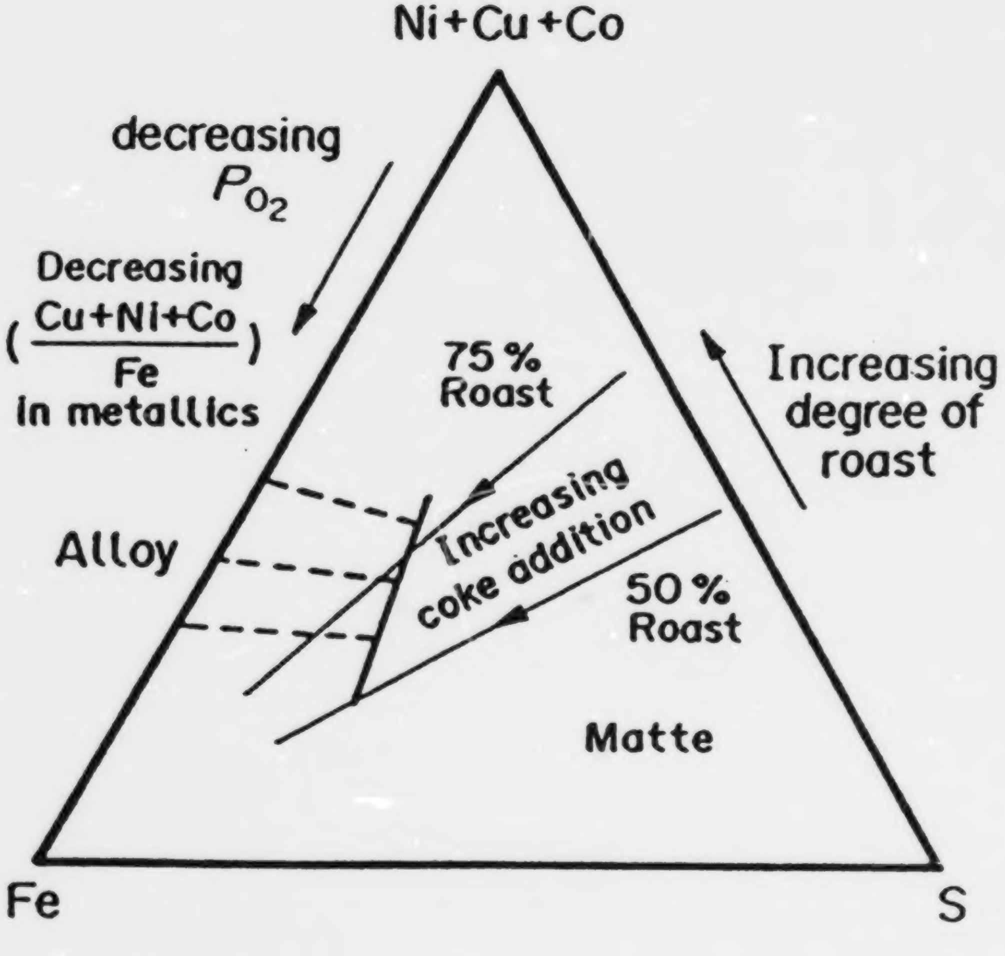
Ni+Cu+Co
decreasing P_{O_2}
Decreasing $\left(\frac{Cu+Ni+Co}{Fe}\right)$ in metallics
75 % Roast
Increasing degree of roast
Increasing coke addition
Alloy
50 % Roast
Matte
Fe
S

Figure 7. The Metallic Saturation Boundary in the Fe-S-(Ni+Cu+Co) System.

A high temperature conductivity apparatus was dismantled and transferred from Falconbridge to the University of Toronto. This equipment consists of a molybdenum crucible conductivity cell supported on a molybdenum pedestal. The pedestal extends to the furnace bottom and provides the electrical contact to the crucible. A molybdenum probe mounted to a precision movement device can be lowered down the center of the crucible into the molten slag sample. The cell resistance of the slag between the crucible and the probe is measured by applying a current with a frequency of 1000 cycles per second. Some of the parameters investigated include: temperature, Fe/SiO_2 ratio, lime content, and Fe_2O_3 additions to the slag. It was determined that increases in temperature and Fe/SiO_2, as well as additions of CaO and hematite all tend to increase the electrical conductivity of the slag. These results are presented graphically in Figures 8 and 9. The 'master slag' was obtained from Falconbridge Limited's electric furnaces.

These data are necessary in order to predict how the electric furnace will behave as the slag chemistry is altered. For example, it may be necessary to raise the temperature of the slag in order to control hearth buildups as more coke is added to the furnace. Also, it was determined in the first part of this contract that lime additions to the charge suppress the release of SO_2 during smelting. These additions cannot be made to the furnace without examining how they will affect furnace operation.

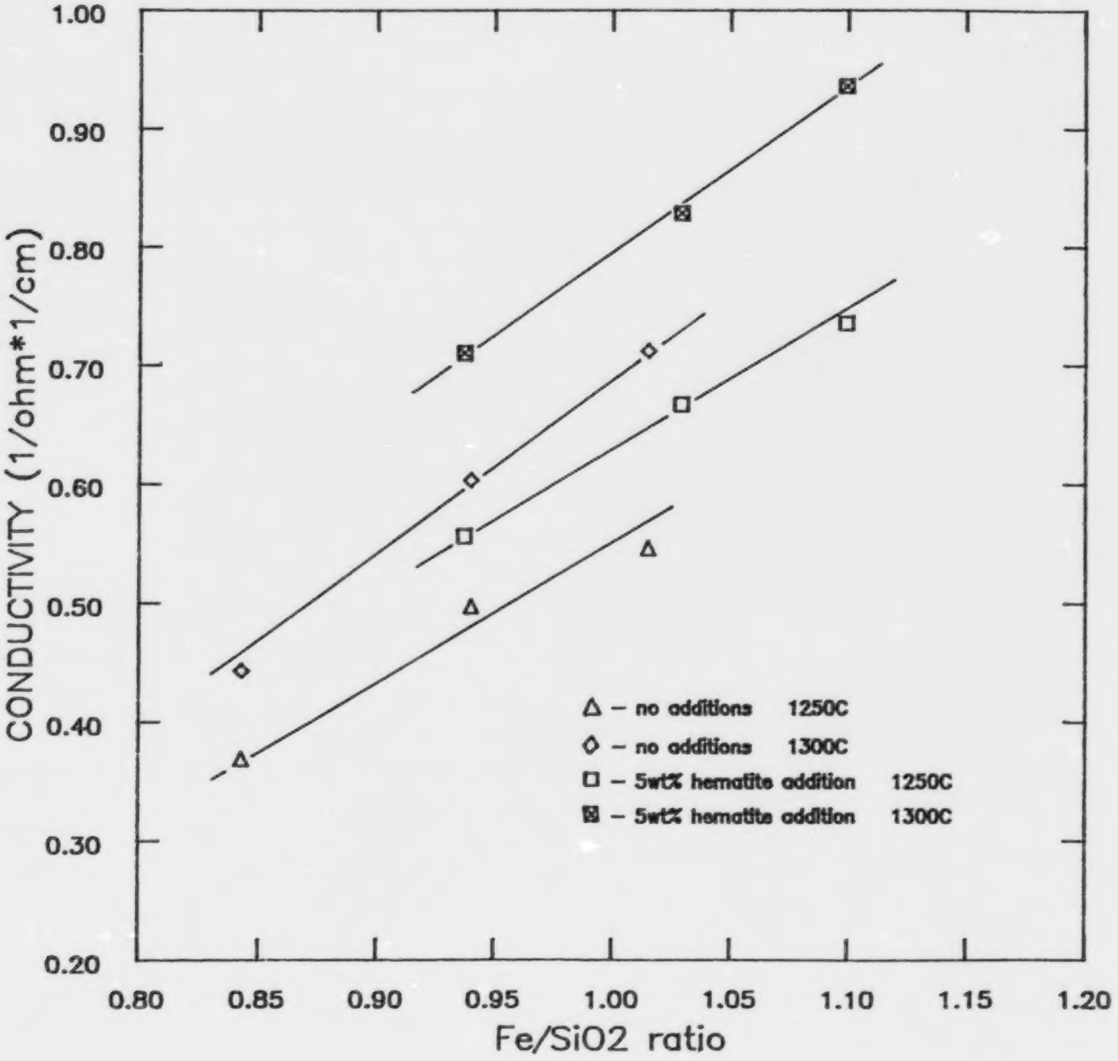

Figure 8. Effect of Fe/SiO$_2$ Ratio and Hematite Addition on Electrical Conductivity.

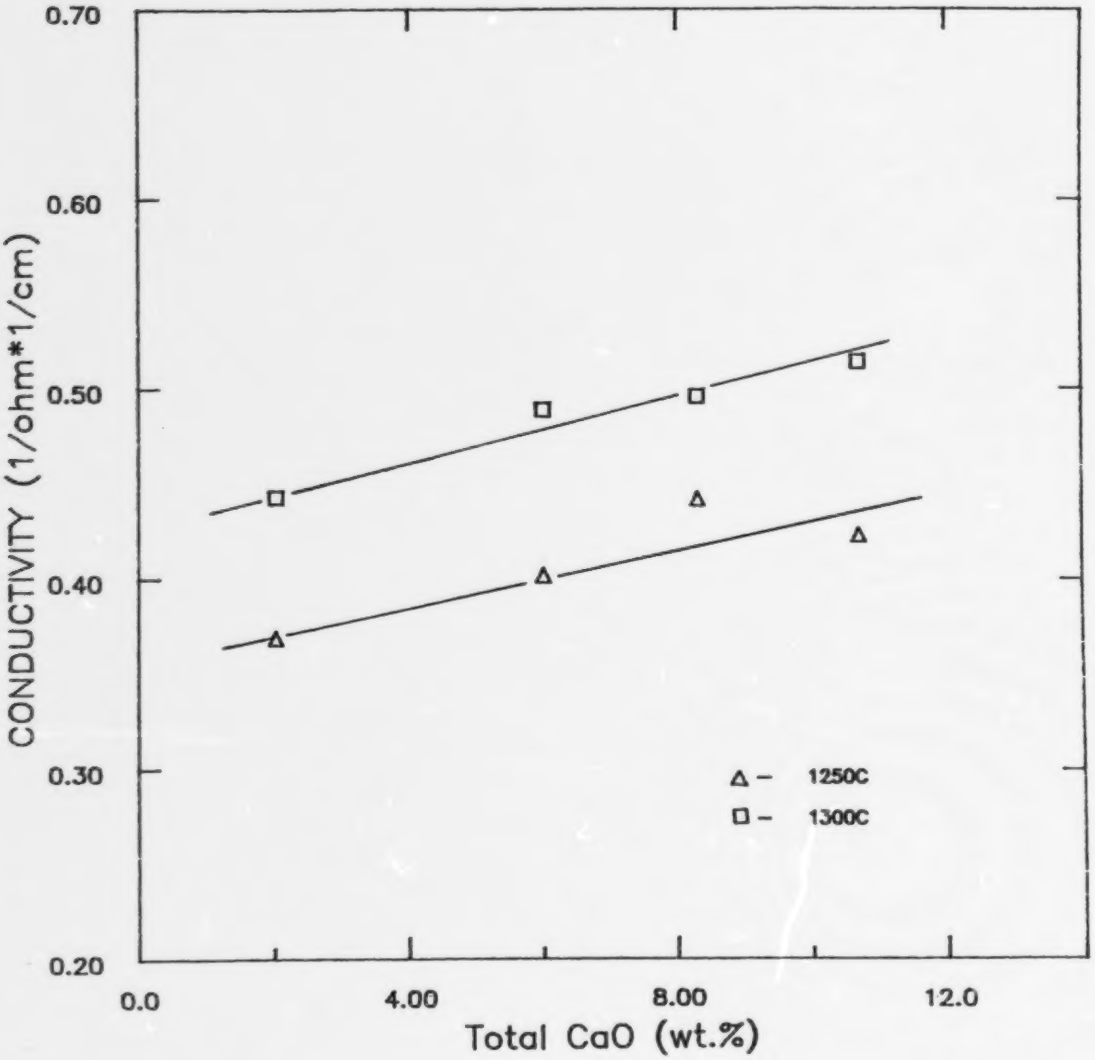

Figure 9. Effect of CaO Additions on Electrical Conductivity.

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